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HOW THE SEA-DEPTHS ARE EXPLORED.

ONE of the most recent and impressive examples of the interaction of science and art by which knowledge is extended, and man's control over Nature increased, is furnished by the late remarkable investigations into the depths and life of the sea. The taking of soundings is, of course, as old as navigation, and is an indispensable portion of the mariner's art. The record of these soundings was embodied in charts by which sailors were guided in unknown waters. As commerce extended, such observations became more full, and resulted in systematic coast-surveys in which the depth of water, currents, magnetic conditions, temperatures, tides, and winds, were taken into account, and the knowledge thus accumulated gave rise at length to a great science—the Physical Geography of the Sea. About twenty-five years ago a new step was taken toward the extension of our knowledge of sea-depths. Science had given to the world the electric telegraph, and commerce demanded that it should be laid across the ocean. For this purpose the bed of the North Atlantic required to be carefully examined and mapped, and the configuration of the sea-bottom and the nature of its material determined. This gave a new impulse to the art of sea-sounding. The transatlantic cable was laid, got broken, and the end of it was then fished up from a depth of nearly two miles. A great victory was thus gained; the bottom of the sea was no longer inaccessible, and the possibility of its scientific exploration became established. Hitherto, sea observations had main reference to the advantages of navigation and commerce; but, from this time forward, the idea was entertained of pursuing the investigation in the interest of science alone. At the instance of the Royal Society, the British Admiralty, in 1868, granted a small government vessel, the gunboat Lightning, to Dr. William B. Carpenter and Prof. Wyville Thomson, to be used for dredging the bottom of the sea, and investigating its animal life. So promising were the results of

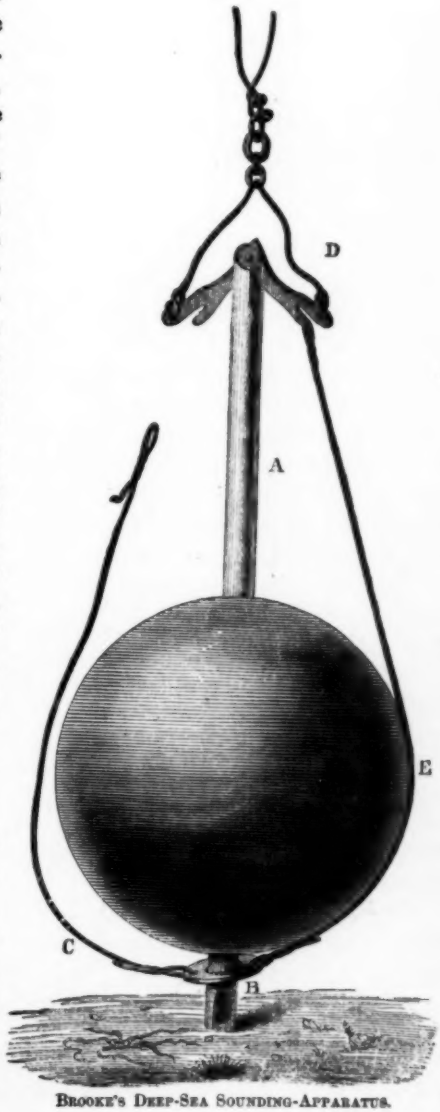
this experiment, that a second expedition was arranged in 1869, and the government surveying-vessel Porcupine was assigned to the naturalists to carry on the work. This expedition was also so highly successful, that the ship Challenger has now started out on a four years' voyage around the world to carry out a comprehensive plan of deep-sea observations. We noticed very briefly last month the admirable work of Prof. Wyville Thomson on "The Depths of the Sea," giving a history of what has been lately done in the investigation of the subject. We propose now to lay Prof. Thomson's work under contribution for the benefit of our readers, and especially to give some account of the instruments of ocean-research, and the way the exploration is conducted.

It may be remarked, in passing, that, when the dredging of the deep seas was found to be feasible, questions of large scientific interest and moment, which had been hitherto regarded as inaccessible, were suddenly brought within the range of practical solution. It was a popular opinion, shared also by men of science, that the bottom of the sea was a dark and desolate waste, subject to such tremendous pressure as to render all life impossible. Prof. Thomson observes: "The enormous pressure at these great depths seemed at first sight alone sufficient to put any idea of life out of the question. There was a curious popular notion, in which I well remember sharing when a boy, that, in going down, the sea-water became gradually under the pressure heavier and heavier, and that all the loose things in the sea floated at different levels, according to their specific weight: skeletons of men, anchors, and shot, and cannon, and, last of all, the broad gold-pieces lost in the wreck of many a galleon on the Spanish Main, the whole forming a kind of false bottom to the ocean, beneath which there lay all the depth of clear, still water, which was heavier than molten gold. The conditions of pressure are certainly very extraordinary. At 12,000 feet a man would bear upon his body a weight equal to 20 locomotive-engines, each with a long goods-train loaded with pig-iron. We are apt to forget, however, that water is almost imcompressible, and that, therefore, the density of sea-water at a depth of 12,000 feet is scarcely appreciably increased."

Contrary to all anticipation, it was found that highly-organized representatives of all the invertebrate classes do live under these conditions of enormous pressure. The bottom of the ocean is, therefore, to be regarded as habitable, and is proved to be actually inhabited by numberless forms of animal life. A new world was thus opened to the naturalist, which, although difficult of access, was yet accessible and must be investigated. The pioneers in the exploration of course encountered very formidable obstacles; but the field was too vast and the promise too rich to be neglected, and how it was regarded by the devotees of research may be gathered from the following words of Dr. Thomson:

"Still the thing is possible, and it must be done again and again, as the years pass on, by naturalists of all nations working with improved machinery and with ever-increased knowledge. For the bed of the deep sea, the 140,000,000 square miles which we have now added to the legitimate field of natural-history research, is not a barren waste. It is inhabited by a fauna more rich and varied on account of the enormous extent of the area, and with organisms in many cases apparently even more elaborately and delicately formed, and more exquisitely beautiful in their soft shades of coloring and in the rainbow-tints of their wonderful phosphorescence, than the fauna of the well-known belt of shallow water, teeming with innumerable invertebrate forms, which fringes the land. And the forms of these hitherto unknown living beings, and their mode of life and their relations to other organisms, whether living or extinct, and the phenomena and laws of their geographical distribution, must be worked out."

FIG. 1.

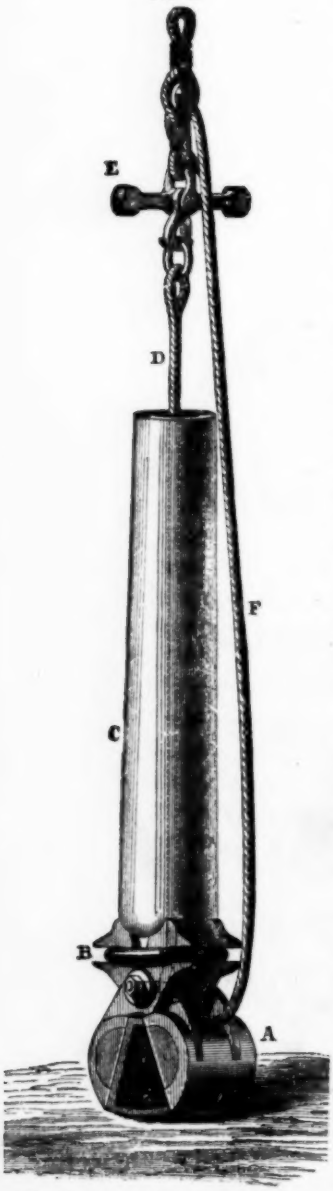


BROOKE'S DEEP-SEA SOUNDING-APPARATUS.

There are two principal operations in exploring the bottom of the ocean: first, sounding to ascertain depth; and, second, dredging to bring up materials. Although much ingenuity has been expended in devices to bring up samples of the sea-bottom by the sounding-apparatus, yet dredging contrivances are now mainly relied upon for that purpose. To determine the depth with a sounding-line, it is customary to graduate it by attaching slips of different-colored cloths or leather which mark it off into sections, and give the means of determining the distance to which

the weight runs down. Another method of measuring the depth consisted in running down a weight attached to a line, which was cut at the surface as soon as the weight was supposed to have reached bottom, from a sudden change in the rate of running out, and the depth was then calculated by the length of cord left on the reel.

Fig. 2.



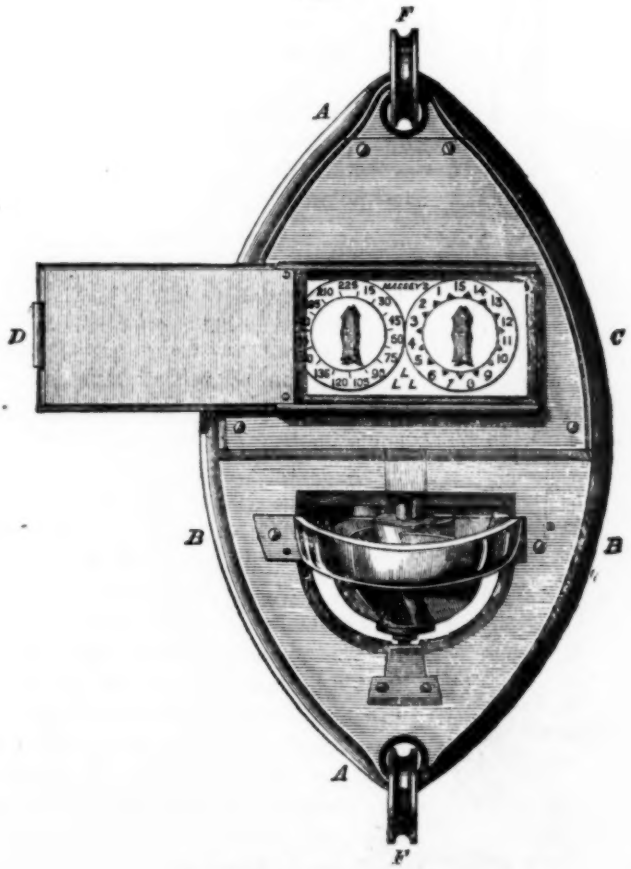
The Bull-dog Sounding-Machine.

The ordinary system of sounding fails at great depths, and cannot be depended upon for more than 6,000 feet. The weight is not sufficient to carry the line rapidly and vertically to the bottom, and, if a heavier weight be used, the line is in danger of breaking. No impulse is felt when the lead strikes the bottom, and the line goes on running out, and, if stopped, is liable to break. Sometimes the line is carried along by submarine currents, forming loops or bights, and it often continues to run out and coil itself in a tangled mass directly over the lead. These sources of error vitiate very deep soundings, so that the reports that have been made of measurements in the Atlantic of 39,000, 46,000, and 50,000 feet, without reaching bottom, are now regarded as exaggerations. In the last charts of the North Atlantic, on the authority of Rear-Admiral Richards, no soundings are entered beyond 24,000 feet, and very few beyond 18,000 feet.

The ordinary deep-sea lead, which is a prismatic block about two feet in length, and from 80 to 120 pounds in weight, has a simple provision for bringing up material from the bottom, which is called "arming"—that is, the lower end, which is slightly cupped, is covered with a thick coating of soft tallow. If it reaches the bottom, mud, shells, gravel, ooze, or sand, sticks to the tallow, and, when drawn up, affords a sample of the nature of the ground. As the interest in the bottom of the sea increased, there was a more eager curiosity to scrutinize the particles thus procured for chemical and microscopical

examination, and it became desirable to devise means of bringing up larger amounts of matter. Many contrivances have been made for this purpose. Sir John Ross, in 1818, invented a machine for this purpose, called the "deep-sea clamm." A large pair of forceps were kept asunder by a bolt, and the instrument was so contrived that, on the bolt striking the ground, a heavy iron weight slipped down a spindle and closed the forceps, which retained within them a considerable quantity of the bottom, whether sand, mud, or small stones. By this arrangement Sir John Ross brought up six pounds of soft mud from a depth of 6,300 feet.

Fig 3.



Massey's Sounding-Machine.

In the year 1854, J. M. Brooke, passed midshipman in the United States Navy, contrived the arrangement known as "Brooke's Deep-Sea Sounding-Apparatus," of which all the more recent contrivances have been to a great extent modifications and improvements, his funda-

mental principle being the detachment of a weight when the bottom is struck. The weight is a 64-pound shot (E, Fig. 1), cast with a hole through it. An iron rod (A B) passes through this hole, with an opening or chamber at the lower end "armed" with tallow. When the instrument strikes, the end of the rod is driven into the material of the bottom, which fills the chamber. At the same time a pair of hinged arms (D) at the top, which were upright in the descent, fall down and release the cord (C), which sustains the ball by a leather collar below. As the loops of the sling are relieved from the teeth of the arms, the rod slips through the hole in the shot, and comes up alone with its enclosed sample of sediment. The difficulty with this machine was the washing out of the material in the ascent. This was remedied by Commander Dayman, by adapting a valve, opening inward, to the terminal chamber of the rod.

In 1860 the assistant engineer of H. M. S. Bull-dog contrived a dredging-lead that combined the principle of Ross's clamm with the disengaging weight of Brooke. It is an ingenious and well-known machine, though hardly as simple as could be desired. Prof. Thomson thus describes it:

Fig. 4.

Otho Friedrich Muller's Dredge, A. D. 1750.

"A pair of scoops (A) close upon one another scissors-wise on a hinge, and have two pairs of appendages (B), which stand to the opening and closing of the scoops in the relation of scissor-handles. This apparatus is permanently attached to the sounding-line by the rope (F), which in the figure is represented as hanging loose, and which is fixed to the spindle on which the cups turn. Attached to the same spindle is the rope (D), which ends above an iron ring. E represents a pair of tumbler-hooks, fastened likewise to the end of the sounding-line; C a heavy leaden or iron weight, with a hole through it wide enough to allow the rope (D) with its loop and ring to pass freely; and B a strong India-rubber band, which passes round the handles of the scoops. In the figure the instrument is represented as it is sent down and before it reaches the bottom. The weight (C) and the scoops (A) are now suspended by the rope (D), whose ring is caught by the tumbler-hooks (E). The elastic ring (B) is in a state of tension, ready to draw together the scoop-handles and close the scoops, but it is antagonized by the weight (C), which, pressing down into a space between the handles, keeps them asunder. The moment the scoops are driven into the ground by

the weight, the tension on the rope (D) is relaxed, the tumblers fall and release the ring, and the weight falls and allows the elastic band to close the scoops and keep them closed upon whatever they may contain; the rope (D) slips through the weight, and the closed scoops are drawn up by the rope (F)."

The attempt has been often made to measure the amount of vertical descent by self-registering machinery. Massey's sounding-machine is the best for this purpose, and operates upon a principle of screw-motion as it falls through the water. As represented in Fig. 3, two thimbles (F F) pass through the two ends of the heavy oval brass shield (A A). To the upper of these the sounding-line is attached, and to the lower the weight at about a yard from the machine. The screw-motion is communicated by a set of four brass vanes or rings (B), which are soldered obliquely to an axis in such a position that, as the machine descends, the axis revolves by the pressure of the water against the vanes. C represents the dial-plate as seen when the slide (D) is withdrawn. The revolving axis communicates its motion to the indices, which are so adjusted that the index on the right-hand dial passes through a division for every fathom of vertical descent, whether quick or slow, and makes an entire revolution for 15 fathoms; while the left-hand index passes through a division on the circle for 15 fathoms, and makes an entire revolution during a descent of 225 fathoms. This instrument answers very well for accurate work in moderately deep water; but at extreme depths it has an uncertainty which seems to be shared by all contrivances involving metal wheel-work.

The main theatre of sounding operations has been the Atlantic Ocean, which, from its relation to the leading commercial nations, and for intercontinental telegraphic purposes, has been more carefully surveyed than any other great body of water. Open from pole to pole, participating in all conditions of climate, communicating freely with other seas, and covering 30,000,000 square miles, it is believed to represent general oceanic conditions, and to contain depths nearly, if not quite, as great as the other ocean-basins of the world, although but little is known, it is true, in this respect, of the Indian, Antarctic, and Pacific Seas. The general result of its soundings would indicate that the average depth of the Atlantic bed is not much more than 12,000 feet, and there seem to be few depressions deeper than 15,000 or 20,000 feet, a little more than the height of Mont Blanc. Dr. Thomson sums up the general results of the Atlantic soundings as follows: "In the Arctic Sea there is deep water, reaching to 9,000 feet to the west and south-west of Spitzbergen. Extending from the coast of Norway, and including Iceland, the Färöe Islands, Shetland and Orkney, Great Britain and Ireland, and the bed of the North Sea to the coast of France, there is a wide plateau, on which the depth rarely reaches 3,000 feet; but to the west of Iceland and communicating doubtless with the deep

water in the Spitzbergen Sea, a trough 500 miles wide, and, in some places, nearly 12,000 feet deep, curves along the east coast of Greenland. This is the path of one of the great Arctic return-currents.

Fig. 5.

Ball's Dredge.

After sloping gradually to a depth of 3,000 feet to the westward of the coast of Ireland in latitude 52°, the bottom suddenly dips to 10,000 feet at the rate of about 15 to 19 feet in the 100; and from this point to within about 200 miles of the coast of Newfoundland, when it begins to shoal again, there is a vast undulating submarine plain, averaging about 12,000 feet in depth below the surface—the 'telegraph plateau.'

"A valley about 500 miles wide, and with a mean depth of 15,000 feet, stretches from off the southwest coast of Ireland, along the coast of Europe, dipping into the Bay of Biscay, past the Strait of Gibraltar, and along the west coast of Africa. Opposite the Cape de Verde Islands, it seems to merge into a slightly deeper trough, which occupies the axis of the South Atlantic, and passes into the Antarctic Sea. A nearly similar valley curves around the coast of North America, about 12,000 feet in depth, off Newfoundland and Labrador, and becoming considerably deeper to the southward, where it follows the outline of the coast of the States, and the Bahamas and Windward Islands, and finally joins the central trough of the South Atlantic off the coast of Brazil, with a depth of 15,000 feet."

Until within a hundred years but little was known of the living inhabitants of the deep sea, except the few objects that adhered to lead-lines, or were taken accidentally by fishermen in trawls and oyster-dredges; and, as odd things of no market value were generally thrown away, the knowledge from this source increased but slowly. The first dredge used by a naturalist to collect specimens from the sea-bottom was employed by Otho Friedrich Müller, who published a quaint book about it in 1779. His dredge was a square-mouthed bag (Fig. 4), and he does not appear to have used it beyond a depth of 180 feet. The dredges now used by naturalists are modifications of the oyster-dredge, which is described as a light frame of iron, about

five feet long by a foot or so in width at the mouth, with a scraper like a narrow hoe on one side, and a suspending apparatus attached to the rope on the other. From the frame is suspended a bag, about two feet in depth, of wide netting or hempen cord. The naturalists' dredge has a scraper on each side, the bag is deeper, and the meshes so fine as to allow only the water to pass through.

FIG. 6.

DREDGE WITH HEMPEN TANGLES.

Fig. 5 represents the dredge devised by Dr. Ball, of Dublin, and which scraped the surface so perfectly that, when drawn along a drawing-room floor, it would pick up the pence that had been scattered before it. Dr. Thomson states that the most convenient size for

dredging from a small boat, at a less depth than 600 feet, is a frame 18 inches long and five inches in width. The scrapers are three inches wide, and are so set that the distance across between their edges is 7½ inches.

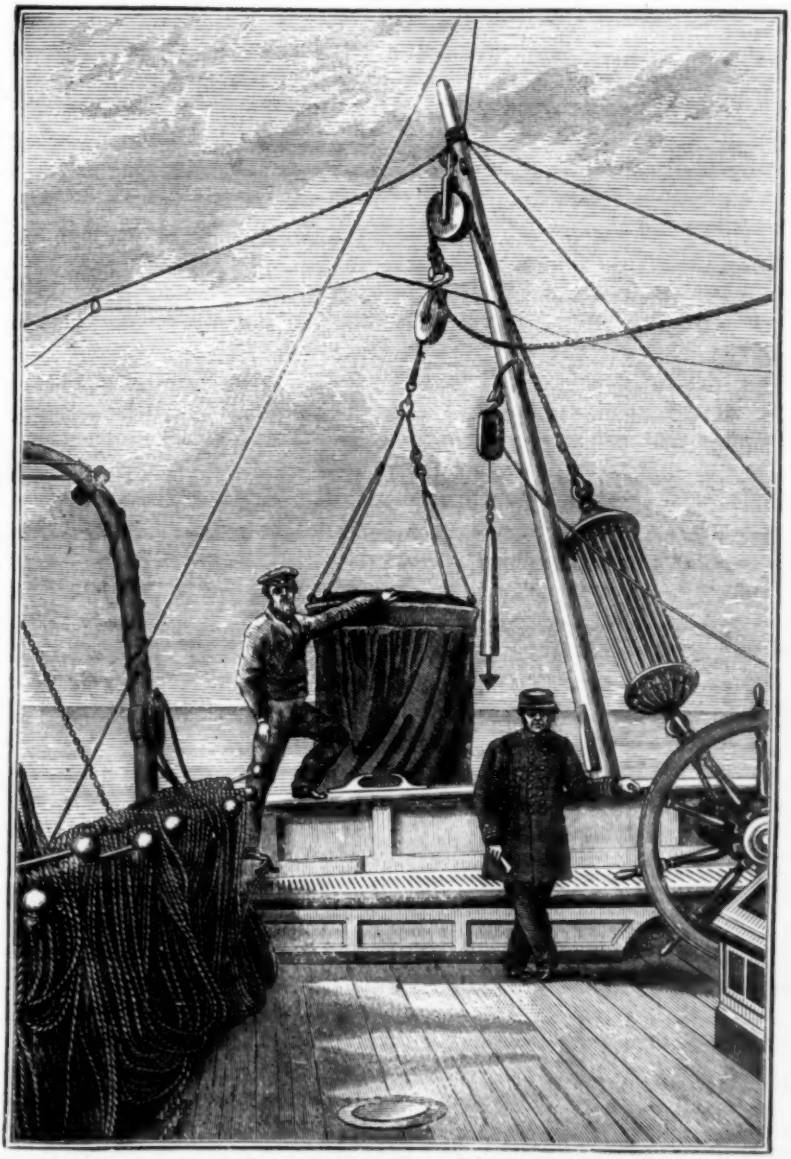
The dredge used for deep-sea work was larger, the frame being four feet six inches in length, and six inches wide at the throat or narrowest part. The weight of the frame was 225 lbs., but Dr. Thomson thinks it was too large and heavy. The dredge-bag was double, the outer being of strong twine netting lined within with "bread-bag," a light, open kind of canvas.

It was found by experience that very often, when nothing of interest was brought up within the dredge, many echinoderms, corals, and sponges, came to the surface, sticking to the outside of the bag, and even to the first few fathoms of the dredge-rope. This suggested the attachment of swabs, used for washing the decks, to the dredge. The tangled hemp turned out to be very efficient, picking up great numbers of objects that would not be otherwise secured. The bag took the mollusks, which, from their shelly forms, could not be otherwise obtained, while the echinoderms, corals, and sponges—bulky objects that could not readily enter the bag—were more easily caught by the swabs, although, unfortunately, it mutilated them, and brought them up in fragments. So important was this expedient, that a long iron bar was attached to the bottom of the dredge-bag, to which the hempen bundles were suspended, as shown in Fig. 6.

The arrangements for sounding and dredging from the Porcupine are fully described and illustrated in Prof. Thomson's work. The vessel was a 382-ton gunboat, with a steam-engine of 12 horse-power, stationed amidships, with drums of different sizes, from which lines were led fore and aft for working either at the bow or stern. Two powerful derricks were rigged for sounding and dredging, one over the stern and one over the port-bow. The block through which the sounding-line or dredging-rope passed was not attached directly to the derrick, but to a rope which passed through an eye at the end of the spar, and was fixed to a "bit," a piece of timber going through the deck. On a bight of this rope between the block and the "bit" was a piece of apparatus shown in Fig. 7, and called the "accumulator." This consisted of 30 or 40 strong India-rubber springs, working together, and its use was to yield by stretching, when, from any cause, as the pitching of the ship, there was an unusual strain upon the line. The dredge-rope of the Porcupine was of Russian hemp, 2½ inches in circumference, with a breaking strain of 2½ tons, and was 18,000 feet, or nearly 3½ miles long. A row of about 20 large iron pins, about 2½ feet in length, projected over one side of the quarter-deck, rising obliquely from the top of the bulwark. Upon these the rope was continuously coiled, as shown in the figure, which also represents the dredge in position for descent.

The method of dredging at a great distance is thus graphically described by Prof. Thomson, as it was performed in the Bay of Biscay, July 22, 1869. The depth was first accurately ascertained by sound-

FIG. 7.



THE STERN DERRICK OF THE PORCUPINE, SHOWING THE "ACCUMULATOR," THE DREDGE, AND THE MODE OF STOWING THE ROPE.

ing, and found to be 14,610 feet. "At 4.45 P. M. the dredge was let go, the vessel drifting slowly before a moderate breeze from the north-

west. The 3,000 fathoms of rope were all out at 5.50 P. M. The diagram (Fig. 8) will give an idea of the various relative positions of the dredge and the vessel according to the plan of dredging adopted by Captain Calvert, which worked admirably, and which appears, in fact,

FIG. 8.

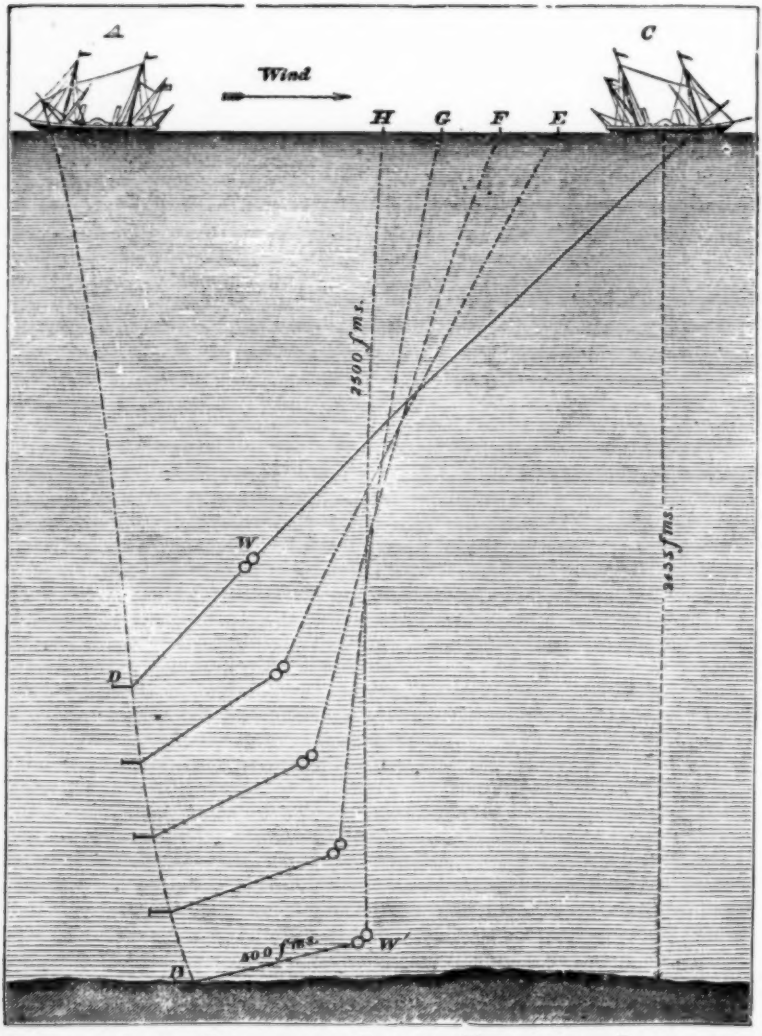


DIAGRAM OF THE RELATIVE POSITIONS OF THE VESSEL, THE WEIGHTS, AND THE DREDGE, IN DREDGING IN DEEP WATER.

to be the only mode that would answer for great depths. It represents the position of the vessel when the dredge is let go, and the dotted line (A B) the line of descent of the dredge rendered oblique by the tension of the rope. While the dredge is going down, the ves-

sel drifts gradually to leeward; and, when the whole (say) 18,000 feet of rope are out, C W and D might represent respectively the relative positions of the vessel, the weight attached 3,000 feet from the dredge, and the dredge itself. The vessel now steams slowly to windward, occupying successively the positions E, F, G, H. The weight, to which the water offers but little resistance, sinks from W to W′, and the dredge and bag sink more slowly from D to B. The vessel is now allowed to drift back before the wind, from H toward C. The tension of the motion of the vessel, instead of acting immediately on the dredge, now drags forward the weight (W′), so that the dredging is carried on from the weight, and not directly from the vessel. The dredge is thus quietly pulled along, with its lip scraping the bottom in the attitude which it assumes from the centre of weight of its iron frame and arms. If, on the other hand, the weights were hung close to the dredge, and the dredge were dragged directly from the vessel, owing to the great weight and spring of the rope, the arms would be continually lifted up, and the lip of the dredge prevented from scraping. In very deep dredging this operation of stealing up to windward until the dredge-rope is nearly perpendicular, after drifting for half an hour or so to leeward, is usually repeated three or four times.

"At 8.50 P. M. we began to haul in. The donkey-engine delivered the rope at the rate of rather more than a foot per second without a single check. A few minutes before one A. M. the weights appeared, and, a little after one in the morning, eight hours after it was cast over, the dredge was safely hauled on deck, having in the interval accomplished a journey of upward of eight statute miles. The dredge contained 1½ cwt. of very characteristic pale-gray Atlantic ooze." The total weight brought up by the engine was:

Weight of rope, reduced to ¼ in water	=	1,375 lbs.
Dredge and bag, " " "	=	275 "
Ooze brought up, " " "	=	168 "
Weight attached		224 "
		2,042

As an abundant and characteristic invertebrate life is now shown to exist at such great depths, it is inferred to extend to *all* depths; and thus the whole ocean-bed becomes in future the domain of the inquisitive naturalist. But, as Dr. Thomson remarks, little more can be said, for his work is all before him: "A grand new field of inquiry has been opened up, but its culture is terribly laborious. Every haul of the dredge brings to light new and unfamiliar forms—forms which link themselves strangely with the inhabitants of past periods in the earth's history; but as yet we have not the data for generalizing the deep-sea fauna, and speculating on its geological and biological relations; for, notwithstanding all our strength and will, the area of the bottom of the deep sea which has been fairly dredged may still be reckoned by the square yard."

THE PHYSIOLOGY OF DEATH.

By FERNAND PAPILLON.

TRANSLATED FROM THE FRENCH, BY A. R. MACDONOUGH.

OF old, the spoils of death fell to the anatomist's share, while the physiologist took for his part the phenomena of life. Now we submit the corpse to the same experiments as the living organism, and pry into the relics of death for the secrets of life. Instead of seeing in the lifeless body mere forms ready to dissolve and vanish, we detect in it forces and persisting activities full of deep instructiveness in their mode of working. As theologians and moralists exhort us to study the spectre of death face to face at times, and strengthen our souls by courageous meditation on our last hour, so medicine regards it as essential to direct our attention toward all the details of that mournful drama, and thus to lead us, through gloom and shadows, to a clearer knowledge of life. But it is only with respect to medicine in the most modern days that this is true.

Leibnitz, who held profound and admirable theories of life, had one of death also, which he has unfolded in a famous letter to Arnauld. He believes that generation is only the development and evolution of an animal already existing in form, and that corruption or death is only the reënvelopment or involution of the same animal, which does not cease to subsist and continue living. The sum of vital energies, consubstantial with monads, does not vary in the world; generation and death are but changes in the order and adjustment of the principles of vitality, simple transformations from small to great, and *vice versa*. In other words, Leibnitz sees everywhere eternal and incorruptible germs of life, which neither perish at all nor begin. What does begin and perish is the organic machine of which these germs compose the original activity: the elementary gearing of the machine is broken apart, but not destroyed. This is the earlier view held by Leibnitz. He has another, conceiving of generation as a progress of life through degrees; he can conceive of death also as a gradual regress of the same principle, that is to say, that in death life withdraws little by little, just as it came forward little by little in generation. Death is no sudden phenomenon, nor instantaneous evanishing—it is a slow operation, a "retrogradation," as the Hanoverian philosopher phrases it. When death shows to us, it has been a long time wearing away the organism, though we have not perceived it, because "dissolution at first attacks parts invisibly small." Yes, death, before it betrays itself to the eye by livid pallor, to the touch by marble coldness, before chaining the movements and stiffening the blood of the dying person, creeps with insidious secrecy into the smallest and most hidden

points of his organs and his humors. Here it begins to corrupt the fluids, to disorganize the tissues, to destroy the equipoise and endanger the harmony. This process is more or less lingering and deceitful, and, when we note the manifest signs of death, we may be sure that the work lacked no deliberate preparation.

These ideas of Leibnitz, like most of the conceptions of genius, waited long after the time of their appearance for confirmation by demonstrative experiment. Before his day, bodies were dissected only for the sake of studying in them the conformation and normal arrangement of the organs. When this study was once completed, science took up the methodical inquiry into the changes produced in the different parts of the body by diseases. Not until the end of the eighteenth century did death in action become the subject of investigation by Bichat.

Bichat is the greatest of the physiological historians of death. The famous work he has left on this subject, his "Physiological Researches upon Life and Death," is as noteworthy for the grandeur of its general ideas, and its beauty of style, as for its precision of facts and nicety of experiment. To this day it remains the richest mine of recorded truths as to the physiology of death. Having determined the fact that life is seriously endangered only by alterations in one of the three essential organs, the brain, the heart, and the lungs, a group forming the vital tripod, Bichat examines how the death of one of these three organs assures that of the others, and in succession the gradual stoppage of all the functions. In our day, the advance of experimental physiology in the path so successfully traversed by Bichat, has brought to light in their minutest details the various mechanical processes of death, and, what is of far greater consequence, has disclosed an entire order of activities heretofore only suspected to be at work in the corpse. The theory of death has been built up by slow degrees along with that of life, and several practical questions that had remained in a state of uncertainty, such as that of the signs of real death, have received the most decisive answer in the course of these researches.

I.

Bichat pointed out that the complete life of animals is made up of two orders of phenomena, those of circulation and nutrition, and those that fix the relations of the living being with its environment. He distinguishes organic life from animal life, properly so called. Vegetables have only the former; animals possess both, intimately blended. Now, on the occurrence of death, these two sorts of life do not disappear at one and the same moment. It is the animal life that suffers the first stroke; the most manifest activities of the nervous system are those which come to a halt before all the rest. How is this stoppage brought about? We must consider separately the order of occur

rences in death from old age, in that occasioned by disease, and in sudden death.

The man who expires at the close of a long decline in years, dies in detail. All his senses in succession are sealed. Sight becomes dim and unsteady, and at last loses the picture of objects. Hearing grows gradually insensible to sounds. Touch is blunted into dulness, odors produce but a weak impression, only taste lingers a little. At the same time that the organs of sensation waste and lose their excitability, the functions of the brain fade out little by little. Imagination becomes unfixed, memory nearly fails, judgment wavers. Further, motions are slow and difficult on account of stiffness in the muscles; the voice breaks; in short, all the functions of outward life lose their spring. Each of the bonds attaching the old man to existence parts by slow degrees. Yet the internal life persists. Nutrition still takes place, but very soon the forces desert the most essential organs. Digestion languishes, the secretions dry up, capillary circulation is clogged: that of the large vessels in their turn is checked, and, at last, the heart's contractions cease. This is the instant of death. The heart is the last thing to die. Such is the series of slow and partial deaths which, with the old man spared by disease, result in the last end of all. The individual who falls into the sleep of eternity in these conditions, dies like the vegetable which, having no consciousness of life, can have no consciousness of death. He passes insensibly from one to the other, and to die thus is to know no pain. The thought of the last hour alarms us only because it puts a sudden end to our relations with all our surroundings; but, if the feeling of these relations has long ago faded away, there can be no place for fear at the brink of the grave. The animal does not tremble in the instant before it ceases to be.

Unfortunately, death of this kind is very rare for humanity. Death from old age has become an extraordinary phenomenon. Most commonly we succumb to a disturbance in the functions of our vital system, which is sometimes sudden, sometimes gradual. In this case, as in the former one, we observe animal life disappearing first, but the modes of its conclusion are infinitely varied. One of the most usual is death through the lungs; as a result of pneumonia and different forms of phthisis, the oxidation of the blood becoming impossible on account of the disorganization of the pulmonary globules, venous blood goes back to the heart without gaining revivification. In the case of serious and prolonged fevers, and of infectious diseases, whether epidemic or otherwise, which are, characteristically, blood-poisonings, death occurs through a general change in nutrition. This is still more the fact as to death consequent upon certain chronic disorders of the digestive organs. When these are affected, the secretion of those juices fitted to dissolve food dries up, and these fluids go through the intestinal canal unemployed. In this case the invalid dies of real

starvation. Hæmorrhage is one of the commonest causes of death. Whenever a great artery is opened from any cause, permitting the copious outflow of blood, the skin grows pale, warmth declines, the breathing is intermittent, vertigo and dimness of sight follow, the expression of the features changes, cold and clammy sweat covers part of the face and the limbs, the pulse gets gradually weaker, and, at last, the heart stops. Virgil describes hæmorrhage with striking fidelity in the story of Dido's death.

Sudden death, unconnected with outward and accidental causes, may occur in various ways. Very violent impressions on the feelings sometimes abruptly check the movements of the heart, and produce a mortal swoon. Instances are well known of many persons dying of joy—Leo X. is one—and of persons who succumbed to fear. In *foudroyant* apoplexy, if real death is not instantaneous, there is at least the sudden occurrence of the phenomena of death. The sufferer is plunged in profound sleep, called by physicians coma, from which wakening is impossible; his breathing is difficult, his eyes set, his mouth twisted and distorted. The pulsations of the heart cease little by little, and soon life utterly vanishes. The breaking of an aneurism very often occasions sudden death. Not less often the cause of death is found in what is called an embolism, that is, a check to the circulation by a clot of blood suddenly plugging up some important vessel. And there are also cases of sudden death still unaccounted for, in the sense that subsequent dissection discovers nothing that could explain the stoppage in the operations of life.

Death is usually preceded by a group of phenomena that has received the name of the death-agony. In most cases of disease the beginning of this concluding period is marked by a sudden improvement of the functions. It is the last gleam springing from the dying flame; but soon the eyes become fixed and insensible to the action of light, the nose grows pointed and cold, the mouth, wide open, seems to call for the air that fails it, the cavity within it is parched, and the lips, as if withered, cling to the curves of the teeth. The last movements of respiration are spasmodic, and a wheezing, and sometimes a marked gurgling sound, may be heard at some distance, caused by obstruction of the bronchial tubes with a quantity of mucus. The breath is cold, the temperature of the skin lowered. If the heart is examined, we note the weakening of its sounds and pulsations. The hand, placed in its neighborhood, feels no throb. Such is the physiognomy of a person in the last moments of death in the greater number of cases, that is, when death follows upon a period of illness of some duration. The death-struggle is seldom painful, and almost always the patient feels nothing of it. He is plunged into a comatose stupor, so that he is no longer conscious of his situation or his sufferings, and he passes insensibly from life to death, in a manner that renders it sometimes difficult to fix the exact instant at which a dying person expires. This is true,

at least, in chronic maladies, and especially in those that consume the human body slowly and silently. Yet, when the hour of death comes for ardent organizations—for great artists, for instance, and they usually die young—there is a quick and sublime new burst of life in the creative genius. There is no better example of this than the angelic end of Beethoven, who, before he breathed out his soul, that tuneful monad, regained his lost speech and hearing, and spent them in repeating for the last time some of those sweet harmonies which he called his "Prayers to God." Some diseases, moreover, are most peculiarly marked by the gentleness of the dying agony. Of all the ills that cheat us while killing by pin-pricks, consumption is that which longest wears for us the illusive look of health, and best conceals the misery of living and the horror of dying. Nothing can be compared with that hallucination of the senses and that liveliness of hope which mark the last days of the consumptive. He takes the burning of his destroying fever for a healthful symptom, he forms his plans, and smiles calmly and cheerfully on his friends, and suddenly, some morrow of a quiet night, he falls into the sleep that never wakes.

If life is everywhere, and if, consequently, death occurs everywhere, in all the elements of the system, what must be thought of that point in the spinal marrow which a famous physiologist styled the vital knot, and in which he professed to lodge the principle of life itself? The point which Flourens regarded as this vital knot is situated nearly at the middle of the prolonged spinal cord—that is, the middle of that portion of the nerve-substance which connects the brain with the spinal marrow. This region, in fact, has a fine and dangerous excitability. A prick, or the penetration of a needle into it, is enough to cause the instant death of any animal whatever. It is the very means used in physiological laboratories to destroy life swiftly and surely in dogs. That susceptibility is explained in the most natural way. This spot is the starting-point of the nerves that go to the lungs; the moment that the slighest injury is produced in it, there follows a check on the movements of respiration, and ensuing death. This vital knot of Flourens enjoys no sort of special prerogative. Life is not more concentrated nor more essential in it than elsewhere; it simply coincides with the initial point of the nerves animating one of the organs indispensable to vitality, the organ of sanguification; and in living organisms any alteration of the nerves controlling a function brings a serious risk as to its complete performance. There is, therefore, no such thing as a vital knot, a central fire of life in animals. They are collections of an infinity of infinitely small living creatures, and each one of these microscopic living points is its own life-centre for itself. Each on its own account grows, produces heat, and displays those characteristic activities which depend upon its structure. Each one, by virtue of a prëstablished harmony, meets all the rest in the

ways that they require; but, just as each lives on its own account, so on its account each dies. And the proof that this is so is found in the fact that certain parts taken from a dead body can be transferred to a living one without suffering any interruption in their physiological activity, and in the fact that many organs which seem dead can be excited anew, awakened out of their torpor, and animated to extremely remarkable vital manifestations. This subject we now proceed to consider.

II.

Death seems to be absolute from the instant that the pulsations of the heart are stopped without renewal, because, the circulation of the blood no longer proceeding, the nutrition of the organs becomes impossible, and nutrition is demanded for the maintenance of physiological harmony; but, as we have said above, there are a thousand little springs in the organism which keep up a certain degree of activity after the great main-spring has ceased to act. There is an infinite number of partial energies that outlive the destruction of the principal energy, and withdraw only by slow degrees. In cases of sudden death especially the tissues keep their peculiar vitality a very long time. In the first place, the heat declines only quite slowly, and the more so in proportion as death has been quick. For several hours after death the hair of the head and body, and the nails, continue to grow, nor does absorption either stop at once. Even digestion, too, keeps on. The experiment performed by Spallanzani to test this is very curious. He conceived the idea of making a crow eat a certain quantity of food, and killing it immediately after the meal. Then he put it in a place kept at the same temperature as that of a live bird, and opened it six hours later. The food was thoroughly digested.

Besides these general manifestations, the dead body is capable, during some continued time, of different kinds of activity. It is not easy to study these on the bodies of persons dying of sickness, because they are not permitted to be made the subject of anatomical examinations until twenty-four hours after death; but the bodies of beheaded criminals, which are given up to *savants* a few moments after their execution, can be of use in the investigation of what takes place immediately after the stopping of the living machine. If the heart is uncovered a few minutes after execution, pulsations are remarked which continue during an hour or longer, at the rate of forty to forty-five a minute, even after the removal of the liver, the stomach, and the intestines. For several hours the muscles retain their excitability, and undergo reflex contractions from the effect of pinching. M. Robin noted the following phenomenon in the case of a criminal an hour after his execution: "The right arm," to quote his description, "being placed obliquely extended at the side of the trunk, with the hand about ten inches away from the hip, I scratched the skin of the chest, at

about the height of the nipple, with the point of a scalpel, over a space of nearly four inches, without making any pressure on the muscles lying beneath. We immediately saw the great pectoral muscle, then the biceps, then the anterior brachial, successively and quickly contract. The result was a movement of approach of the whole arm toward the trunk, with rotation inward of the limb, and half flexion of the forearm upon the arm, a true defensive movement, which threw the hand forward toward the chest as far as the pit of the stomach."

These spontaneous exhibitions of life in a corpse are trifles compared with those excited by means of certain stimulants, particularly of electricity. Aldini, in 1802, subjected two criminals, beheaded at Bologna, to the action of a powerful battery. Influenced by the current, the facial muscles contracted, producing the effect of horrid grimaces. All the limbs were seized with convulsive movements; the bodies seemed to feel the stir of resurrection, and to make efforts to rise. The springs of the system retained the power of answering the electric stimulus for several hours after beheading. A few years later, at Glasgow, Ure made some equally noted experiments on the body of a criminal that had remained more than an hour hanging on the gallows. One of the poles of a battery of 700 pairs having been connected with the spinal marrow below the nape of the neck, and the other brought in contact with the heel, the leg, before bent back on itself, was thrust violently forward, almost throwing down one of the assistants, who had hard work to keep it in place. When one of the poles was placed on the seventh rib, and the other on one of the nerves of the neck, the chest rose and fell, and the abdomen repeated the like movement, as takes place in respiration. On touching a nerve of the eyebrow at the same time with the head, the facial muscles contracted. "Wrath, terror, despair, anguish, and frightful grins, blended in horrible expression on the assassin's countenance."

The most remarkable instance of a momentary reappearance of vital properties, not in the whole organism, but in the head alone, is the famous experiment suggested by Legallois, and carried out for the first time in 1858 by M. Brown-Séquard. This skilful physiologist beheads a dog, taking pains to make the section below the point at which the vertebral arteries enter their bony sheath. Ten minutes afterward he sends the galvanic current into the different parts of the head thus severed from its body, without producing any result of movement. He then fits to the four arteries, the extremities of which appear in the cutting of the neck, little pipes connected by tubes with a reservoir full of fresh oxygenated blood, and guides the injection of this blood into the vessels of the brain. Immediately irregular motions of the eyes and the facial muscles occur, succeeded by the appearance of regular harmonious contractions, seeming to be prompted by the will. The head has regained life. The motions continue to be performed during a quarter of an hour, while the injection of blood

into the cerebral arteries lasts. On stopping the injection, the motions cease, and give place to the spasms of agony, and then to death.

Physiologists asked whether such a momentary resurrection of the functions of life might not be brought about in the human subject—that is, whether movement might not be excited and expression reanimated by injecting fresh blood into a head just severed from a man's body, as in M. Brown-Séquard's experiment. It was suggested to try it on the heads of decapitated criminals, but anatomical observations, particularly those of M. Charles Robin, showed that the arteries of the neck are cut by the guillotine in such a way that air penetrates and fills them. It follows that it is impracticable to inject them with blood that can produce the effects noted by M. Brown-Séquard. Indeed, we know that blood circulating in the vessels becomes frothy on contact with air, and loses fitness for its functions. M. Robin supposes that the experiment in question could be successful only if made upon the head of a man killed by a ball that should strike below the neck; in that case it would be possible to effect such a section of the arteries that no entrance of air would occur, and, if the head were separated at the place pointed out by M. Brown-Séquard, those manifestations of function remarked in the dog's head would probably be obtained by the injection of oxygenated blood. M. Brown-Séquard is convinced that they might be obtained, if certain precautions were observed, even with the head of a decapitated criminal; and, so strong is his conviction, that, when it was proposed to him to try the experiment—that is, to perform the injection of blood into the head of a person executed—he refused to do so, not choosing, as he said, to witness the tortures of this fragment of a being recalled for an instant to sensibility and life. We understand M. Brown-Séquard's scruples, but it is allowable to doubt whether he would have inflicted great suffering on the head of the subject; at most, he would only have aroused in it a degree of very dim and uncertain sensibility. This is easily explained. In life, the slightest perturbation in the cerebral circulation is enough to prevent thought and sensation utterly. Now, if a few drops of blood too much or too little in the brain of an animal in full health suffice to alter the regularity of its psychical manifestations, much more certainly will the completeness of the brain's action be deranged if it is awakened by an injection of foreign blood, a forcible entry too, which, of necessity, cannot cause the blood to circulate with suitable pressure and equipoise.

Corpse-like rigidity is one of the most characteristic phenomena of death. This is a general hardening of the muscles, so great that they lose the property of extension till even the joints cannot be bent; this phenomenon begins some hours after death. The muscles of the lower jaw are the first to stiffen; then rigidity invades in succession the abdominal muscles, those of the neck, and at last the thoracic ones. This hardening takes place through the coagulation of the half-fluid

albuminoid matter which composes the muscular fibres, as the solidification of the blood results from coagulation of its fibrine. After a few hours the coagulated musculine grows fluid again, rigidity passes away, and the muscles relax. Something not dissimilar takes place also in the blood. The globules change, lose shape, and suffer the beginning of dissociation. The agents of putrefaction, vibrios and bacteria, thus enter upon their great work by insidiously breaking up the least seen parts.

At last, when partial revivals are no longer possible, when the last flicker of life has gone out and corpse-like rigidity has ceased, a new work begins. The living germs that had collected on the surface of the body and in the digestive canal develop, multiply, pierce into all the points of the organism, and produce in it a complete separation of the tissues and humors; this is putrefaction. The moment of its appearance varies with the causes of death and the degree of outward temperature. When death is the result of a putrid malady, putrefaction begins almost immediately when the body has grown cold. It is the same when the atmosphere is warm. In general, in our climates, the work of decomposition becomes evident after from thirty-eight to forty hours. Its first effects are noticeable on the skin of the stomach; this takes on a greenish discoloration, which soon spreads and covers successively the whole surface of the body. At the same time the moist parts, the eye, the inside of the mouth, soften and decay; then the cadaverous odor is gradually developed, at first faint and slightly fetid, a mouldy smell, then a pungent and ammoniacal stench. Little by little the flesh sinks in and grows watery; the organs cease to be distinguishable. Every thing is seized upon by what is termed putridity. If the tissues are examined under the microscope at this moment, we no longer recognize any of the anatomical elements of which the organic fabric is made up in its normal state. "Our flesh," Bossuet exclaims in his funeral-sermon on Henrietta of England, "soon changes its nature, our body takes another name; even that of a corpse, used because it still exhibits something of the human figure, does not long remain with it. It becomes a thing without a shape, which in every language is without a name." When structure has wholly disappeared, nothing more remains but a mixture of saline, fat, and proteic matters, which are either dissolved and carried away by water, or slowly burned up by the air's oxygen, and transmuted into new products, and the whole substance of the body, except the skeleton, returns piecemeal to the earth whence it came forth. Thus the ingredients of our organs, the chemical elements of our bodies, turn to mud and dust again. From this mud and this dust issue unceasingly new life and energetic activity; but a clay fit for the commonest uses may also be got from it, and, in the words of Shakespeare's *Hamlet*, the dust of Alexander or Cæsar may plug the vent of a beer-cask, or "stop a hole to keep the wind away." These "base uses," of which the Prince of

Denmark speaks to *Horatio*, mark the extreme limits of the transformation of matter. In any case the beings of lowest order that toil and engender in the bosom of putrefaction are really absorbing and storing away life, since without their aid the corpse could not serve as nutriment to plants, which in their turn are the necessary reservoir whence animality draws its sap and strength. It is in this sense that Buffon's doctrine of organic molecules is a true one.

Death is the necessary end of all organic existence. We may hope more or less to set at a distance its inevitable hour, but it would be madness to dream of its indefinite postponement in any species whatsoever. No doubt there is no contradiction in conceiving of a perfect equilibrium between assimilation and disassimilation, such that the system would be maintained in immortal health. In any case, no one has yet even gained a glimpse of the modes of realizing such an equilibrium, and death continues, till further orders, a fixed law of Fate. Still, though immortality for a complete organism seems chimerical, perhaps it is not the same with the immortality of a separate organ in the sense we now explain. We have already alluded to the experiments of M. Paul Bert on animal-grafting. He has proved that, on the head of a rat, certain organs of the same animal—as the tail, for instance—may be grafted. And this physiologist asks himself the question, whether it would not be possible, when a rat provided with such an appendage draws near the close of his existence, to remove the appendage from him, and transplant it to a young animal, which in his turn would be deprived of the ornament in the same way in his old age in favor of some specimen of a new generation, and so on in succession. This tail, transplanted in regular course to young animals, and imbibing at each transference blood full of vitality, perpetually renewed, yet ever remaining the same, would thus escape death. The experiment, delicate and difficult, as we well see, was yet undertaken by M. Bert, but circumstances did not allow it to be prolonged for any considerable time, and the fact of the perpetuity of an organ, periodically rejuvenated, remains to be demonstrated.

III.

Real death, then, is characterized by the positive ceasing of vital properties and functions both in the organic or vegetative life, and in the animal life, properly so termed. When animal life disappears without any interruption occurring in organic life, the system is in a state of seeming death. In this state the body is possessed by profound sleep quite similar to that of hibernating animals; all the usual expressions and all signs of internal activity have disappeared, and give place to invincible torpor. The most powerful chemical stimulants exert no control over the organs, the walls of the chest are motionless; in short, seeing the body presenting this appearance, it is impossible not to think of it as dead. There are quite numerous states of the or-

ganism which may thus imitate death more or less closely; the commonest one is that of fainting. In this case neither sensation nor movements of circulation or respiration are any longer perceptible; the warmth is lowered, the skin pallid and colorless. Instances of hysteria are cited in which the attack has been prolonged for several days, attended with fainting. In this strange condition all physiological manifestations remain suspended; yet they are not, as it was long supposed, suspended absolutely. M. Bouchest has proved that, in the gravest cases of fainting, the pulsations of the heart continue, weaker and rarer, and harder to be heard than in normal life, but clearly distinguishable when the ear is laid on the precordial region. On the other hand, the muscles retain their suppleness and the limbs their pliability.

Asphyxia, which properly is suspension of breathing, and consequently of the blood's revivification, sometimes passes into a serious fainting condition followed by seeming death, from which the sufferer recovers after a period of varying length. This state may be induced either by drowning or by inhaling a gas unfit for respiration, such as carbonic acid in deep wells, emanations from latrines, or the chokedamp of mines, or by suffocation. In 1650 a woman named Ann Green was hanged at Oxford. She had been hanging for half an hour, and several people, to shorten her suffering, had pulled her by the feet with all their strength. After she was placed in her coffin it was observed that she still breathed. The executioner's assistants attempted to end her existence, but, thanks to the help of physicians, she came back to life, and continued to live some time afterward. Drowning occasions an equally deep insensibility, during which, very singularly, the psychical faculties retain some degree of activity. Sailors, after timely resuscitation from drowning, declare that, while under water, they had returned in thought to their families, and sadly fancied the grief about to be caused by their death. After a few minutes of physical rest, they suffered violent colic of the heart, which seemed to twist itself about in their chests; afterward this anguish was followed by utter annihilation of consciousness. It is very difficult, moreover, to determine how long apparent death may be protracted in an organism under water. It varies greatly with temperaments.

In the islands of the Greek archipelago, where the business of gathering sponges from the bottom of the sea is pursued, children are not allowed to drink wine until, by practice, they have grown accustomed to remain a certain time under water. Old divers of the archipelago say that the time to return and take breath at the surface is indicated to them by painful convulsions of the limbs, and very severe contractions in the region of the heart. This power of enduring asphyxia for some time, and resisting by force of will the movements of respiration, has been remarked under other circumstances. The case of a Hindoo is mentioned, who used to creep into the palisaded enclosures used for

bathing, in the Ganges, by the ladies of Calcutta, seize one of them by the legs, drown her, and rob her of her rings. It was supposed that a crocodile carried her off. One of his intended victims succeeding in escaping, the assassin was seized and executed in 1817. He confessed that he had practised the horrible business for seven years. Another instance is that of a spy, who, seeing preparations making for his execution, endeavored to escape it by feigning death. He held his breath, and suspended all voluntary motions for twelve hours, and endured all the tests applied to him to put the reality of his death beyond doubt. Anæsthetics, too, like chloroform and ether, sometimes produce stronger effects than the surgeons using them desire, and occasion a state of seeming death instead of temporary insensibility.

It is easy to recall persons to life who are in a state of seeming death; it is only needful to stimulate powerfully the two mechanical systems that are more or less completely suspended in action, namely those of respiration and circulation. Such movements are communicated to the frame of the chest, that the lungs are alternately compressed and dilated. A sort of shampooing is applied over the whole body, which restores the capillary circulation; chemical stimulants, such as ammonia or acetic acid, are brought under the patient's nostrils. This is the mode of treatment for drowned persons, whose condition is brought on by ceasing to breathe the air, not by taking in too much water. A very effective method in cases of apparent death, caused by inhaling a poisonous gas, such as carbonic acid or sulphuretted hydrogen, consists in making the patient draw in large quantities of pure oxygen. And, again, it has very lately been proposed, as Hallé suggested without success early in this century, to adopt the use of strong electric currents for stimulating movement in persons who are in a state of syncope.

In all the cases of seeming death we have just mentioned, one mark of vitality persistently remains, that is, pulsation of the heart. Its throbs are less strong and frequent, but they continue perceptible on auscultation. They are regularly discernible in the deepest fainting-fits, in the various kinds of asphyxia, in poisonings by the most violent narcotics, in hysteria, in the torpor of epilepsy, in short, in the most diverse and protracted states of lethargy and seeming death.

Yet, this result, now a practical certainty, was unknown to physicians of old, and it cannot be denied that, in former times, seeming death was quite often mistaken for true death. The annals of science have recorded a certain number of errors of this kind, many of which have resulted in the interment of unfortunate wretches who were not dead. And for one of these mistakes that chance has brought to light either too late, or in time for the rescue, even then, of the victim, how many are there, particularly in times of ignorance and carelessness, that no one has ever known! How many live men have only given

up their last breath after a vain struggle to break out of their coffin! The facts collected by Bruhier and Lallemand in two works that have become classic compose a most mournful and dramatic history. These are some of its episodes, marked by the strange part that chance plays in them. A rural guard, having no family, dies in a little village of Lower Charente. Hardly grown cold, his body is taken out of bed, and laid on a straw ticking covered with a coarse cloth. An old hired woman is charged with the watch over the bed of death. At the foot of the corpse were a branch of box, put into a vessel filled with holy water, and a lighted taper. Toward midnight the old watcher, yielding to the invincible need of sleep, fell into a deep slumber. Two hours later she awoke surrounded by flames from a fire that had caught her clothes. She rushed out, crying with all her might for help, and the neighbors, running together at her screams, saw in a moment a naked spectre issue from the hut, limping and hobbling on limbs covered with burns. While the old woman slept, a spark had probably dropped on the straw bed, and the fire it kindled had aroused both the watcher from her sleep and the guard from his seeming death. With timely assistance he recovered from his burns, and grew sound and well again.

On the 15th of October, 1842, a farmer in the neighborhood of Neufchâtel, in the Lower Seine, climbed into a loft over his barn to sleep, as he usually did, among the hay. Early the next day, his customary hour of rising being past, his wife, wishing to know the cause of his delay, went to look for him, and found him dead. At the time of interment, more than twenty-four hours after, the bearers placed the body in a coffin, which was closed, and carried it slowly down the ladder by which they had gained the loft. Suddenly one of the rounds of the ladder snapped, and the bearers fell together with the coffin, which burst open with the shock. The accident, which might have been fatal to a live man, was very serviceable to the dead one, who was roused from his lethargy by the concussion, returned to life, and hastened to get out of his shroud with the assistance of those of the bystanders who had not been frightened away by his sudden resurrection. An hour later he could recognize his friends, and felt no uneasiness except a slight confusion in his head, and the next day was able to go to work again. At about the same time a resident of Nantes gave up life after a long illness. His heirs made arrangements for a grand funeral, and, while the performance of a requiem was going on, the dead man returned to life and stirred in the coffin, that stood in the middle of the church. When carried home, he soon regained his health. Some time afterward, the *curé*, not caring to be at the trouble of the burial ceremonies for nothing, sent a bill to the ex-corpse, who declined to pay it, and referred the *curé* to the heirs who had given orders for the funeral. A lawsuit followed, with which the papers of the day kept the public greatly amused. A few years ago Cardinal

Donnet, in the Senate, told his own story of the circumstances under which he narrowly escaped being buried alive.

Besides these instances of premature burial in which the victim escaped the fearful consequences of the mistake made, others may be cited in which the blunder was discovered only too late. Quite a number of such cases are known, some of which are told with details too romantic to entitle them to implicit belief, while, however, many of them show unquestionable signs of authenticity. There long prevailed a tradition, not easily traceable to any source, which attributed the death of the Abbé Prévost to a mistake of this kind. All his biographers relate that the famous author of "Manon Lescaut," falling senseless from the effect of a rush of blood, in the heart of the forest of Chantilly, was supposed to be dead; that then the surgeon of the village having made an incision into his stomach, by direction of the magistrate, to ascertain the cause of death, Prévost uttered a cry, and did then die in earnest. But it has since been proved that the story is imaginary, and that it was made up after Prévost's death; nor do any of the necrological accounts published at the time refer it to the consequences of a premature autopsy. Though the account of Prévost dissected alive seems doubtful, that is not the case with the story told with regard to an operation by the famous accoucheur, Philip Small. A woman, about to be confined, fell into a state of seeming death. Small relates that when he was summoned to perform the Cesarean operation, the by-standers, convinced that the woman was dead, urged him to proceed with it. "I supposed so, too," he says, "for I felt no pulse in the region of the heart, and a glass held over her face showed no sign of respiration." Then he plunged his knife into the body, and was cutting among the bleeding tissues, when the subject awoke from her lethargy.

We cite some still more startling instances. Thirty years ago, a resident of the village of Eymes, in Dordogne, had been suffering for a long time from a chronic disorder of little consequence in itself, but marked by the distressing symptom of constant wakefulness, which forbade the patient any kind of rest. Worn out with this condition, he consulted a doctor, who prescribed opium, advising great caution in its use. The invalid, possessed with that common-enough notion that the efficacy of a drug is proportioned to its quantity, took at one time a dose sufficient for several days. He soon fell into a deep sleep, which continued unbroken for more than twenty-four hours. The village doctor, being summoned, finds the body without warmth, the pulse extinct, and, on opening the veins of both arms in succession, obtains but a few drops of thick blood. The day after, they prepared for his burial. But, a few days later, closer inquiry revealed the imprudence the poor wretch had committed in taking an excessive quantity of the prescribed narcotic. The report spreading among the villagers, they insist on his disinterment, which is allowed. Gathering in a crowd, at

the cemetery, they take up the coffin, open it, and are met by a horrible sight. The miserable man had turned over in his coffin, the blood gushing from the two opened veins had soaked the shroud; his features were frightfully contorted, and his convulsed limbs bore witness to the cruel anguish that had preceded death. Most of the facts of this kind are of rather remote date. The latest instances have happened in the country, among an ignorant population, usually in neighborhoods where no physician was called on to ascertain the decease, that is, to distinguish the cases of seeming death from those of true death.

How, then, can we certainly know apparent from real death? There is a certain number of positive signs of death; that is to say, signs which, when absolutely discerned, leave no room for mistake. Yet some physicians, and many people who know nothing of science, are still so doubtful about the certainty of these signs as to wish that physiology could detect others of a more positive character. A zealous philanthropist, quite lately, gave a sum for a prize of twenty thousand francs to the discoverer of an infallible sign of death. Doubtless, the intention is excellent, but we are safe henceforward in regarding the sexton's work without alarm; the signs already known are clear enough to prevent any mistake, and to make the fatal risk of premature burial impossible.

We must point out, in the first place, the immediate signs of death. The first, and the most decisive, is the absolute stoppage of the heart's pulsations, noted for a duration of at least five minutes, not by the touch, but by the ear. "Death is certain," says the reporter of the commission named in 1848, by the Academy of Sciences, to award the prize of competition as to the signs of true death, "when positive cessation of pulsations of the heart in the subject has been ascertained, which is immediately followed, if it has not been preceded, by cessation of respiration, and of the functions of sensation and motion." The remote signs equally deserve attention. Of these, three are recognized: corpse-like rigidity, resistance to the action of galvanic currents, and putrefaction. As we have already seen, rigidity does not begin till several hours after death, while general and complete disappearance of muscular contractility, under the stimulus of currents, and, last of all, putrefaction, are only manifest at a still later period. These remote signs, particularly the last, have this advantage, that they may be ascertained by those unacquainted with medicine, and it is very well to pay some attention to them in countries where physicians are not charged with the verification of the disease, but they are of no importance wherever there are doctors to examine the heart with instruments, and to decide promptly and surely upon the death, from the complete stoppage of pulsation in that organ. At the beginning of the century, Hufeland, and several other physicians, convinced that all the signs of death then known were uncertain, except putrefaction, proposed and obtained, in Germany, the establishment of a certain number of mortuary houses, intended to receive, and keep for some time, the bodies

of deceased persons. During the whole existence of these establishments, not one of the bodies transported into those asylums has been known to return to life, as the authentic declarations of the attendant doctors agree. The usefulness of such mortuary houses is still more questionable in our time, when we have a positive and certain means of recognizing real death. Those police regulations that forbid autopsies and interments until the full term of delay for twenty-four hours, measured from the declaration of death, still remain prudent precautions, but they do not lessen at all the certainty of that evidence furnished by the stopping of the heart. When the heart has definitely ceased to beat, then resurrection is no longer possible, and the life which deserts it is preparing to enter upon a new cycle.

Hamlet, in his famous soliloquy, speaks of "that undiscovered country from whose bourn no traveller returns," and mournfully asks, what must be the dreams of the man to whom death has opened the portals of those gloomy regions. We can give no clearer answer, in the name of physiology, than Shakespeare's prince gives. Physiology is dumb as to the destiny of the soul after death; of that it teaches, and it can teach us, nothing. It is plain, and it would be childish to deny it, that any psychical or sentient manifestation, and any concrete representation of the personality, are impossible after death. The dissolution of the organism annihilates surely, and of necessity, the functions of sensation, motion, and will, which are inseparable from a certain combination of material conditions. We can feel, move, and will, only so far as we have organs for reception, transmission, and execution. These assurances of science are above discussion, and should be accepted without reserve. Do they tell us any thing of the destiny of the psychical principles themselves? Again we say, No, and for the very simple reason that science does not attain to those principles; but metaphysics, which does attain to them, authorizes us, nay, further, compels us to believe that they are immortal. They are immortal, as the principles of motion, the principles of perception, all the active unities of the world, are immortal. What is the general characteristic of those unities? It is that of being simple, which means being indestructible, which means being in harmonious mutual connection, after such a manner that each one of them perceives the infinite order of the other. If this connection did not exist, there would be no world. What is the characteristic of the psychical unities more especially? It is that of having, besides the consciousness of such perception, the feeling also of the relations that bind the whole together, and those faculties, more or less developed, which that consciousness and that perception imply. But why should these unities be any more perishable than the others? Why, if all these forces, all these activities, are eternal, should those alone not possess eternity which have this high privilege, that of knowing the infinite relations which the others sustain without knowing that they do so?

To form a conception of the immortality of the soul, then, we must place ourselves at that point of view to which men rarely and hardly rise, of the simplicity and the indefectibility of all those principles of force that fill the universe. We must train ourselves to understand that what we see is nothing in comparison with what we do not see. The whole force, the whole spring, of the most complex movements, the most magnificent phenomena of Nature, and the most subtle operations of life, thought included, proceed from the infinite commingling of an infinity of series of invisible and unextended principles, whose activities ascend in the scale of perfection from simple power of movement up to supreme reason. Human personality, such as we see and know it, is only a coarse and complex result from those of these primitive activities which are the best and deepest thing in us. It is not that personality which is immortal—that is no more immortal than the motive force of a steam-engine is, or the electricity of a voltaic battery, although movement and electricity are of themselves indestructible. It is not that personality which can aspire to a home in the bosom of God. Our true personality, our real *I*, that which may without illusion count on a future life, is unity released from every material bond, and all concrete alloy; it is that force, necessarily pure, which has a more or less clear consciousness of its own relations with the infinity of like unities, and which more or less draws near to them by thought and by love. It is beyond our power to conceive what will become of that unity when, quitting its prison of flesh, and soaring into the ideal ether, it will no longer have organs with which to act; but what we can affirm is that, precisely by reason of this freedom, it will rise to a clearer knowledge of all that it had only known obscurely, and to a purer love of what it had adored only through the veil of sense. And this certainty, which is the ennobling and elevating force of life, is also the consolation for death.—*Revue des Deux Mondes.*

NATURE AND ORIGIN OF THE DRIFT-DEPOSITS OF THE NORTHWEST.

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II. *Origin of the Drift.*

THE first records of exact observations pertaining to the drift seem to have been made in the first quarter of the present century, and are wholly confined to the appearances and positions of the bowlders, or "travelled rocks," that constitute a striking object to the scientific observer throughout the northern portions of Europe and America. In 1819 the memoirs of the Wernerian Society of Edinburgh

announced the transportation by ice of a large piece of conglomerate 4 × 6 × 8 feet a distance of 260 yards in one night. It was deposited in the sands on the shores of a little bay on the Mersey Firth.

A similar account is published in the *American Journal of Science and Arts*, 1822, as occurring at Salisbury, Connecticut.

After the year 1820, exact observations were stimulated in this country by the publication of the *American Journal of Science and Arts*, which from time to time called attention to the various phenomena of the drift. The earliest investigations of note were made by De Saussure, Pallas, and De Luc, on the Continent of Europe, and by Sir James Hall in Scotland. These observers coincided in the opinion that the existence of the "travelled rocks" must be explained by the occurrence of devastating currents of water, or *débâcles*, from the north, which transported them from their original places. This theory was advocated, sometimes with slight modifications, by the revered Dr. Edward Hitchcock, of Massachusetts; by Dr. Benjamin Silliman, of Connecticut; by Dr. Hildreth, of Ohio; Lapham, of Wisconsin; J. N. Nicollet, of Minnesota; and by Von Buch, Studer, Buckland, and De la Beche, of Europe. Von Buch, seeing that one *débâcle*, proposed by De Saussure, would not account for all the phenomena, supposed there were several. De la Beche believed this vast inundation from the north was the immediate result of a sudden upheaval of the polar regions, turning the waters of the Arctic Ocean southward with great violence. This cause was also accepted by Prof. Buckland and Dr. Silliman. This theory is the same as that known as *diluvion*. Hence the groovings on the rocks were first known as *diluvial* marks.

Contemporary with the *débâcle* theory was that of Chabrier, who believed the bowlders came from the atmosphere. This theory seems not to have met with very much countenance, and soon ceased to be regarded.

In 1828 Peter Dobson, of Connecticut, proposed the germ of what became an important and long-lived theory, viz., that floating ice, in the form of vast sheets, carried great quantities of gravel and stones, and distributed them wherever they were stranded. This suggestion, aided by the quick indorsement of Sir R. I. Murchison, grew into that known as the iceberg theory, which survives to the present day. This last necessitates the submergence of the continent beneath the quiet waters of the ocean, and here diverges from the *débâcle* theory which requires turbulent waters. The iceberg theory received many prominent and able advocates. Among them may be named Sir Charles Lyell, Sir Roderick I. Murchison, Peter Dobson, John L. Hays, C. T. Jackson, Sedgwick, of England; W. C. Redfield, of New England; Prof. Mather, of Ohio; Dawson, of Canada; and a great many others.

Before, however, the iceberg theory had grown into prominence, Mr. De Kay, of New York, proposed another, which at least has the

advantage of allowing the continent to stand still instead of sinking it several thousand feet below the ocean-level.

Mr. De Kay claimed that the bowlders originated at or near the places in which they now lie; that they are the remains of ancient peaks of primitive rock that have since been demolished by earthquakes and by atmospheric forces, the sites covered by detritus, and concealed from the observer. This was announced in 1828, but it made no headway, probably from the fact that these bowlders lie on the surface not only where primitive rocks abound, but also over broad areas where the primitive rocks are buried thousands of feet below later sedimentary formations, such formations being intact over the whole area.

In 1837 Prof. Louis Agassiz propounded that theory known as the glacier theory in a paper read before the Helvetic Society of Natural History in his native country, Switzerland. It is thus concisely stated by Mr. Charles McLaren: "It was deduced from a careful study of the phenomena attending glaciers. . . . The Swiss philosopher advanced step by step. He satisfied himself that in the Alpine valleys, where glaciers still exist, they once rose to a higher level, and extended farther down into the low country than they now do. Next he discovered indications of their former existence on Mont Jura and over the whole Swiss valley; and, connecting these with similar indications found in the Vosges, the Scandinavian mountains, and elsewhere, and with the well-known fact of sheets of ice covering the northern shores of Siberia, and entombing the remains of extinct species of animals, he came to the conclusion that, at a period, geologically speaking, very recent, all the Old World north of the 35th or 36th parallel had been enveloped in a crust of ice. Whence the cold came which produced this effect, and why it afterward disappeared, are questions he did not feel himself bound to answer." This theory had been suggested before by Venetz, but had been applied by him only to the region of the Alps. Prof. Agassiz afterward more fully worked out his theory, giving facts, and careful measurements, and calculations, in his famous work entitled "Études sur les Glaciers."

Prof. Agassiz supposes that the eastern Alps were upheaved when the coating of ice was on the surface, this being the last cataclysm that has visited Europe. By this upheaval of the Alps the ice was disturbed, like the rocky formations. This was accompanied or followed by a higher temperature, and the thawing of the ice, which produced torrents and consequent valleys of erosion. The floods which followed the upheaval of the Alps were sufficient to float icebergs containing blocks of rock that might be deposited in different places, the water being at least 300 feet deep, and the agent that carried and deposited the fine drift in the valleys below. The catastrophe which enveloped the northern regions in ice was sudden, according to Prof. Agassiz, but the retreat of the glacier was slow.

This theory, so novel, so startling, met with various acceptance. By some it was loudly scouted as the product of the imagination solely; and was classed by Prof. B. Studer, a *savant* of the Continent of Europe, with the poetical Indian legends, wherein the periods of heat and life are made to alternate with periods of freezing and death. But its force lay in the inherent evidence of candor, and honesty in the statement of facts about which there could be no dispute. By the most enlightened geologists, both of the Old World and the New, it was received as a flood of light cast on what had before been dark and unexplained; and it was accepted with some caution and exceptions by such men as Prof. Buckland, Sir Charles Lyell, and Prof. Edward Hitchcock. At the present day but few geologists can be found in this country who do not admit the reality of the glacial epoch.

But, while it is true that but few geologists can be found in this country who do not admit the truth of the glacier theory of Prof. Agassiz, it is also true that a great many, perhaps the majority, also adhere to the iceberg theory of Peter Dobson. The two theories at first came in violent conflict. They diverged at the outset. One required the continent below the ocean, and the transportation of bowlders and other drift by floating ice; the other required it elevated high above the ocean, and the transportation of the drift by ice in the form of continental glaciers. How, then, can the same person hold to both theories?

Soon after the promulgation of the glacier theory by Prof. Louis Agassiz, Mr. Charles McLaren attempted to make it harmonize with the iceberg theory. He was seconded in the effort by Prof. Edward Hitchcock, who invented the term *aqueo-glacial*, to express the force, or forces, that operated to disperse the materials of the drift. In explaining the meaning of that term, he says, however, he cannot admit the glacier theory of Prof. Agassiz, and apply it unqualifiedly to this country; but, while acknowledging himself greatly indebted to Agassiz, he thinks that icebergs were the principal agents in transporting the drift. In the years 1841 and 1842 Sir Charles Lyell visited this country. His observations on the drift, published in various scientific journals, and repeated in his book of "Travels in North America," in 1845, furnish the basis for the most plausible union of these two theories. He divides the drift epoch into four parts:

1. The period of emergence of the land, during which some of the bold, rocky escarpments of the continent were formed.

2. A gradual subsidence and moderate submergence of the interior portions of the continent, during which icebergs floated over the surface of the ocean, grinding and marking the rocks.

3. The deposition of the clay, gravel, and sand, of the drift, with occasional fragments of rock, the last through floating ice.

4. Period of reëlevation and formation of lake-terraces.

Although not professedly aiming to reconcile the iceberg theory

with the glacier theory of M. Agassiz, Mr. Lyell's eminent authority would not permit the total extinguishment of the iceberg theory, and his generalizations have, perhaps, had more influence in directing the efforts of others in such reconciliation than the writings of any other man. It required but very slight changes in Mr. Lyell's method of dividing the history of the drift to evolve, in its present aspect, the latest theory of geologists touching the origin of the drift-deposits. Mr. Murchison, of England, coincides with Mr. Lyell in the submergence, or iceberg theory. Mr. J. D. Dana advocates the glacier theory in its fullest extent; but, although adopting also the term *Champlain*, he is far from admitting the recent enlargement of that epoch, so as to bring the continent beneath the water of the ocean as required by the supporters of the combination theory.

Professors E. W. Hilgard, of Mississippi, and J. S. Newberry, of Ohio, are among the most prominent advocates in this country of this new theory, resulting from the combination of the glacier and the iceberg theories. Dr. A. Winchell, of New York, also advocates the same. It is as follows:

First. The glacier epoch proper.

During this epoch the continent was considerably elevated above its present level, especially in the north. This either produced, or was accompanied by, a greater degree of cold, the effect of which was to bring over the continent the vast sheets of ice in the form of continental glaciers, required by the hypothesis of Prof. Agassiz. During this epoch the rocks were scored, and many deep valleys were excavated. Large bowlders were transported to regions farther south.

Second. The submergence of the continent, attended by an amelioration of the climate and the disappearance of the glaciers, or their retreat to the far north. The assortment and stratification of the drift, produced by the glaciers, and the deposition of the great mass known as *Erie clay*, and other clayey portions of the drift-sheet. This condition of the continent was attended by the appearance of numerous icebergs which floated over the submerged land, and aided to transport the coarse drift, according to the hypothesis of Peter Dobson.

Third. The emergence of the continent with a halting progress, producing terraces and ridges marking the ancient levels of the ocean.

These three steps have been named by Prof. Dana, in their order, the *Glacial Epoch*, the *Champlain Epoch*, and the *Terrace Epoch*.

The studies of Professors Agassiz and Tyndall on the glaciers of the Alps, and of Dr. Kane on those of Greenland, have so fully demonstrated the adequacy of glaciers to produce all the effects attributed to them by the theory of Agassiz, that it is now very generally admitted that, wherever those phenomena are seen, glaciers must have existed.

Geology, having demonstrated thus the necessity for a period of cold, to account for the phenomena of the surface of the earth, labored

under the difficult task of accounting for such change of climate on philosophical principles. It is here that the community of the sciences is beautifully illustrated. Astronomy comes to the aid of her younger sister, and Geology receives from her the solution she could not herself compass.

Astronomy makes known three great irregularities in the motions of the earth, requiring thousands of years each for their recurrence. They are—

1. The "precession of the equinoxes," combined with the revolution of the line of the apsides, produces a progression in longitude, of the aphelion place of the earth, bringing about a coincidence of the winter-solstice with the aphelion once in 21,356 years. At the present time our aphelion position occurs in the summer season.

2. Variation of the inclination of the earth's axis to the plane of its orbit. This passes through a double oscillation in about ten thousand years. Its effect is to carry the solstitial point through a small variation in latitude, and to that extent prolonging or withdrawing the influence of the sun's rays in the polar regions.

3. Change in the eccentricity of the earth's orbit. This irregularity passes from maximum to maximum once in about one hundred thousand years. Its effect is to lengthen those seasons nearest the earth's aphelion, and to shorten those nearest its perihelion. At the present time, our aphelion, occurring in the summer season, lengthens the warm months to that amount that, combined with the shortening effect of perihelion in winter, makes a difference of about eight days between the summer and winter months of the year.

The conditions favorable for polar glaciation are as follows:

1. Winter-solstice in aphelion.
2. Obliquity of the ecliptic at minimum.
3. Eccentricity of orbit in maximum.

The coincidence of these three causes would produce the greatest glaciation. The least multiple of their periods of recurrence is about forty-two million years. The second cause may combine a great many times with either of the others within that interval. Its effect being quite inferior to that of either of the other two, it may be disregarded, and the time required for the combination of the other two would then be 4,200,000 years, which would necessarily be preceded and followed by a number of approximations. These would occasion corresponding periods of increase and diminution in the degree of cold that would not reach the maximum cold incident to their coincidence. Probably the most powerful of the causes enumerated is the occurrence of the winter-solstice in aphelion, which alone may have produced the last glacial epoch. In that case changes in the prevalence of the ice would be due to the operation of cause No. 2, or the obliquity of the ecliptic. The earth is now 622 years past its period of south-polar glaciation in the operation of cause No. 1, and is entering

upon its period of north-polar glaciation. Its last glacial epoch in the operation of this cause occurred in the Northern Hemisphere in its acme of intensity at a period 11,300 years ago.

The effect of these irregularities in the motions of the earth on the climate has been ably discussed by Mr. James Croll, of the Geological Survey of Scotland ("Transactions of the Geological Society of Glasgow," vol. ii., part iii., p. 177), and detailed calculations on the periodicity of these variations have been made by Mr. Stockwell, of Cleveland, Ohio.

Let us endeavor to picture the recurrence of one of these coincidences, and to rehearse some of the phenomena of an actual period of continental ice.

The precipitation of the winter season is all preserved on the ground in the form of snow and ice. It constitutes what has been denominated *névé*. The advent of the summer season is not powerful enough to melt the accumulations of the long winter. The *névé* is simply converted into granulated ice. Another winter adds to the thickness left by the preceding. Another summer changes it to ice. Some water may be the result, but it is congealed in the streams, or perhaps escapes to the ocean. This succession is continued, with a slow increment of cold, through thousands of years. The ice-mantle becomes continental in its extent. Its thickness reaches hundreds of feet. Toward the pole this may be increased to thousands or tens of thousands. It has a great weight. It presses upon itself. Its lower portions yield to the inequalities of the rocky surface. The mass seeks the valleys. It slides down the mountain-sides, carrying the *débris* which it detaches in its descent. It covers the broad plains. The accumulations toward the north, ever increasing, press out toward the south, the foot of the ice-sheet. A general movement is developed by reason of the gravity of the mass, the fracturing and regelation of its parts, and the molecular forces that allow it to yield under pressure. Each recurring summer develops more or less water. This water perhaps enters the openings and crevasses, and washes out some of the obstructions, facilitating the general progress. The main water-sheds separating valleys serve also as ice-sheds. The valleys are more rapidly dug out by the rasping and ploughing movement of the glacier than are the highlands. In the valleys the ice flows most rapidly. In the valleys, also, the ice is prolonged much farther into warmer latitudes than on the highlands. Southward, prolongations of the ice-sheet follow the north-south outcropping edges of argillaceous formations. Lake Michigan lies in one of these troughs. Lake Huron lies in another. Lakes Erie and Ontario are only shallow basins dug out of soft rocks by ice that passed southwestwardly. The shale-bed that gave rise to Lake Ontario also determined the location of Georgian Bay and of Green Bay. The basin of Lake Erie is much shallower toward the west end than toward the east, and it finally runs out alto-

gether by reason of the westward attenuation, and finally the entire disappearance of the *salina* formation in which it is largely excavated. The ice was then thrust up on to harder rocks that form the basis of Northwestern Ohio and Northeastern Indiana. Lake Michigan was terminated southwardly by the eastward trend of the rocky outcrops at an angle that the ice could not follow. The Red-River flats of Minnesota correspond to the Winnipeg basin in the same way that the Black-Swamp district of Ohio does to the Lake-Erie basin, or the prairie district surrounding the southern end of Lake Michigan does to the basin of that lake.

It must be remembered, however, that throughout the continuance of the ice-period the motion of the ice brought it finally into a climate where it could not exist as ice. It gave rise to countless streams of water. The broad, level country of the Northwest was not sufficiently irregular to gather the ice, and consequently not the water, into valleys having a north-south direction. The water from the ice acted all along the ice-foot with a comparatively uniform energy. If it was ultimately gathered into large streams, it must have been at considerable distances from the glacial field. It must be remembered also that the accumulated precipitation of the entire year over broad, continental areas was preserved from thaw till it arrived at the latitude of the limitation of the glacier, and there its full volume was discharged. It was as if the entire precipitation of the continent—say from the latitude of Chicago to the north-pole—were concentrated on a belt of territory, say of fifty miles in width, running east and west across the continent, and having the direction of the marginal line of the ice-foot. Thus a constant sheet of turbid, running water would act on all objects over which the ice-foot retreated.

We must not forget, in recalling to our imagination the scenes and events of the ice-period, to inquire what were the position and the condition of the drift to which it gave origin.

In regions far to the north, the eye probably would not be able to discern any object except that of the universal ice. The surface of the ground would be thousands of feet below the traveller, if we may be permitted to presume so hardy a human being. Like Dr. Kane exploring the great Humboldt Glacier of Greenland, he would meet with countless obstacles and dangers. But those obstacles would consist of hummocky ice, or crevassed ice, or perpendicular ice-walls. He would see no soil, no rocks, no vegetation, no animal life. The winds would whistle, storms would rage, snow would be drifted about, and the ineffectual sun would rarely venture to smile on the dreary waste. Farther to the south, the explorer would find isolated spots of bare ground. He would see about them the accumulated *débris* of bowlders, gravel, and dust, from constant winds, spread more or less over the ice-field, staining its painful whiteness, and showing the more grateful aspect of earth and stones. Another hundred miles farther south,

and he finds the evidences of the dissolution of the ice-sheet multiplying. Occasional streams of water run on the surface of the ice, or plunge into some of its openings. Deep gorges reveal multitudes of fragments of rock frozen into the ice, and occasional bands of dirt and gravel embraced in the solid ice. The surface is everywhere dirty, or perhaps muddy, from the wasting away of the surface of the glacier. He meets frequent openings, in which generally water may be seen or heard. Into these gorges the *débris* slides down the sloping sides, increasing the insecurity of his footsteps. Still farther south, the general surface is covered with a pulpy earth, mingled with stones and bowlders. The ice is evidently much attenuated. The areas of firm, uncovered *terra firma* are wonderfully increased in size and frequency. The ice itself is crowded into the valleys, or, if it be in a broad, level tract, like the State of Minnesota, the surface is covered with the *débris* of the conflict of ice with earth, the ice itself being visible only in those places where crevasses reveal it, or where deep gorges are worn by running streams. Travelling still farther south, the explorer would come upon large areas in which he would not be able to know whether the glacier underlay the superficial drift or not. If he were to stop on one of those wide areas, and make his latitude and longitude certain, by a series of astronomical observations, he might find to his surprise, after a few years' residence, that his observatory and apparatus had been bodily carried, by an imperceptible motion, some rods to the south. If he were to penetrate the earth on which his foothold seems so steadfast, he might find, equally to his surprise, that he was still riding on the surface of a vast ice-sheet, the earth and soil of which may have furnished him annual crops of potatoes and barley. In other places in the same latitude he would find the ice laid bare over considerable areas, washed clean by the drainage incident to the dissolution of the glacier. The turbid streams would be vastly larger than those which occupy the same beds to-day. They would run with tenfold more violence. The drift-materials would be freed from the clayey portions, and be spread along their channels in curious and varying assortment. In some places the thickness of the whole sheet of drift would be brought under this washing and stratifying process. In others, the ice gently dies out, and lets it down on the rocky surface without any change from the condition in which it lay on the glacier.

If, at last, the explorer travels far enough south to actually leave the area of the glacier, what is the condition of the surface? *It is plainly one of glacier-drift.* In some places he will find the various parts, such as gravel-stones, sand, clay, and bowlders, confusedly mingled, showing no assortment or stratification. The clay which has resulted from the grinding action of the glacier on the surface on which it lay, from dust blown over the ice by violent winds, as in the Alps, and from the sediment washed on the ice from the higher knobs that first became uncovered, fills all the interstices so closely as to make of

the mass an impervious and uniform hard-pan. This has generally been denominated "unmodified drift." It is that which escaped the assorting action of the water issuing from the glacier. In other places, this unmodified drift would be superficially assorted, showing the effect of running water after its deposition or in the act of deposition. Probably very much of that portion of the drift that lay in the course of the broad Mississippi, yet south of the limit of the glacier, would be superficially worked over, losing much of its clay. We actually see vast tracts on the Upper Mississippi, and even in the latitude of St. Paul, in which the surface consists, to a considerable depth, principally of stratified sand and gravel. He would also find parallel ridges of drift-materials, consisting largely of the coarser portions, and showing stratification where water passed over or through it in being deposited. Some such ridges would still retain the most or all of the original clayey portions. This would be the case where the drainage was not powerful. Such ridges mark the places at which the retreat of the ice was temporarily stopped by a period of greater cold, the slow advancing of the ice under the propulsive forces already named serving to heap up a greater amount of detritus all along the ice-margin. These ridges are known as *moraines*, and they occur in all parts of the drift-latitudes. They are developed on a very grand scale in Northwestern Ohio.

There is still one important point in this discussion that must not be omitted. It is plain to see that, in some parts of the Northwest, the advance of the continental glacier would be up gentle slopes, instead of descending an incline. These slopes, of course, present obstructions to the movement of the ice in those directions. It is true, also, that the continental glacier would tend to level the country and obliterate such northward slopes. But, in the later part of the ice period, the valleys would be the last relinquished, and would be deeper dug by isolated branches or spurs from the main ice-sheet, which would conform in their direction to the contour of the valleys they might occupy. All glaciers, however, whether continental or local, would avoid an ascent if there were any other passage. Now, when a glacier, propelled by a force exerted far to the north, meets with a gentle slope toward the north, the water which issues from its foot will be confined in a lake about the foot of the ice, and will rise to the height of the lowest outlet. Into this lake may flow streams of considerable size, bringing their sediment from the south, east, or west, according to the topography. Here we should have, then, a constant accession of drift from two sources, the chief of which would be, of course, the glacier itself. As this drift is brought under the influence of standing water, its fine parts are floated away by currents and waves, to be spread over the bottom of the lake in horizontal laminations, the principal portion, and notably the bowlders, sinking at once to the bottom unassorted. Thus, by the continued slow withdrawal of the field of

ice, the result is a layer of unassorted drift overlaid by a thickness of handsomely-laminated fine clay and sand. This combination of circumstances must have occurred south of Lakes Erie and Huron, producing the Black Swamp and the Cottonwood Swamp in Ohio and Michigan, about the south end of Lake Michigan, and over an extensive flat south of the Winnipeg basin.

All the phenomena of the drift in the Northwest are, hence, attributable to the approach, long duration, and slow disappearance of the glacier-ice of Prof. L. Agassiz. It certainly seems unwarrantable to propose upward and downward movements of the crust, involving the submergence of the continent, when one simpler cause can be shown sufficient to produce the known effects. The submergence of the New-England coast to the depth of about seventy feet is all that Prof. J. D. Dana finds warranted by a vigorous inspection of the drift-deposits about New Haven, Connecticut. The four-hundred-foot "beach," near Montreal, may have the same origin as the so-called "beaches" that rise several hundred feet higher in the State of Ohio. The Champlain and Terrace Epochs find no application to the drift in the Northwest, as those terms are defined and used in the East. There is abundant evidence throughout the West of a former higher stage of the rivers. This higher stage may, however, be explained by referring it to the large increase of water incident to the melting of the glacier only after reaching the latitude of a warmer climate. The terraces have not, moreover, in the Northwest, generally that system or uniformity of height and arrangement necessary to warrant their reference to successive reductions in the volume of water, but are usually due to a variable resistance offered by the banks or rocks in which they occur, arising from their stratification.

No well-authenticated fossil remains from the hard-pan drift have yet been met with. Statements have been published of the finding of fossil remains in the unmodified drift in various parts of the Northwest, but they are generally based on the reports of non-scientific observers, and must be taken with great caution, unless verified by a geologist who has definite ideas of what "modified" or "unmodified" drift is. It would not be improbable that, near the southern margin of the ice-field, the remains of vegetation, and even of animals, should be involved in the drift undergoing transportation, but their structures are too fragile to withstand the grinding incident to the general progress of the ice, and would not bear transportation from northern latitudes. Much uncertainty is also thrown on the true age of vegetable remains, reported from the drift in the Northwest, by the wide-spread but hardly distinguishable clays of the Tertiary and Cretaceous formations, which contain modern species of wood and leaves, associated with marine fossils.

Believing, therefore, in the *glacier* origin, directly, of the Post-Tertiary deposits of the Northwest, it is impossible to concur in the suppo-

sition recently expressed by an eminent authority relative to the probable blending of those deposits with the marine deposits of the Tertiary: "A careful study of these modern deposits" (meaning the Quaternary) "will undoubtedly show consecutive links by which it was united to the Tertiary period, in the same manner as the Cretaceous and Tertiary are connected."[1] It is difficult to conceive how the sedimentary deposits of an epoch of submergence, like the Tertiary, which abound in marine fossils, can show, however carefully studied, consecutive links of connection with an epoch of *débris* transported and deposited through the agency of vast continental glaciers.

St. Anthony, Minnesota, *March*, 1873.

DOMESTIC ECONOMY OF FUEL.

By Captain DOUGLAS GALTON, C.B., F.R.S.

II.

THE question of saving fuel for cooking purposes is even more important than economy in warming; because cooking is an operation required every day in the year, and the waste of fuel in cooking is even more considerable than in warming.

An ordinary cooking-range in houses, which, for convenience, may be designated middle-class houses, is derived from the time when the same fire was used for cooking and for warming. It is interesting to consider Count Rumford's remarks on this question. He largely developed the use of steam for cooking in large establishments, but, in considering private kitchens, he showed that nine-tenths of the heat produced in cooking operations were wasted, and only one-tenth utilized in cooking, by the use of open fireplaces. He laid down the following principles on fireplace construction:

1. Each fireplace should have its grate on which the fuel must be placed, and its separate ash-pit, which must be closed by a door well fitted in its frame and furnished with a register for regulating the quantity of air admitted into the fireplace through the grate. It should also have its separate canal for carrying off the smoke into the chimney, which canal should be furnished with a damper or register. By means of this damper and of the ash-pit door, the rapidity of combustion and generation of heat is regulated, and on the proper use of the two registers the economy of fuel will much depend.

3. In fireplaces for all boilers which are too heavy to be easily lifted with the hand, an opening just above the level of the grate should be made for introducing fuel to the fire, which opening must

[1] Prof. F. V. Hayden, in "Geology of Wyoming."

be closed by a close-fitting stopper or door. In fireplaces constructed for small stew-pans this opening may be omitted, and the fuel be introduced through the opening into which the stew-pan is fitted, by removing the stew-pan occasionally for the purpose.

4. All portable stew-pans should be circular, and suspended in their fireplace from the circular rim. The best form for large fixed boilers is an oblong square, broad and shallow rather than narrow, and deep, and it should be of thin metal.

5. All boilers and stew-pans should be fitted with covers to render them well adapted for confining the heat. The best arrangement is to make the covers of thin sheets of tinned iron, and double, that is, with an air space between the outer and inner cover.

We have, during the last twenty years, introduced, as a rule, close ranges. They are certainly cleaner and more convenient for cooking, and, if great care is exercised in the use of the dampers, they will be found more economical than open fires. But, as a rule, they are based on the principle of making one fire perform a variety of operations. Independently of the question of a combined fire, as compared with the separate fires advocated by Count Rumford, a consideration of the form of modern kitchen-ranges will show that most of the principles laid down by him have been entirely neglected. The doors of the fireplace and ash-pit seldom fit close; the boilers are rather deep and narrow than broad and shallow; the use of the hot-plate prevents the stew-pans from being suspended from the rims for the fire to play round them; the use of double covers for saucepans and boilers is rather a rarity than a usual arrangement.

To realize the question of economy of fuel, it is necessary to consider, in the first place, what a given quantity of fuel is capable of doing. As regards hot water, if water is kept at a temperature of 200°, or from that to 210°, the gases from the fire can, after communicating the heat to the boiler, pass off into the chimney at a temperature of little beyond that point; but, if the water be allowed to boil, in the first place a large amount of latent heat is absorbed by the steam, which is lost if the steam passes off into the air or the chimney, and, in the second place, it will be found that the gases, after they pass off from the boiler, will have a temperature of as much as 300°, 400°, and even 500°. Unless, therefore, water is required to be actually boiling for use, if the water is permitted to boil, a great quantity of heat is wasted up the chimney. For household purposes it is never necessary that the water in the boiler should exceed 200°. Tea, to be good, should be made (as clearly shown by Mr. Francis Galton in his "Art of Travel") with water of a temperature of from 180° to 200°. Very few culinary operations require the water really to boil, and, when boiling water is wanted, it is required in a saucepan standing on the fire. All operations of cleaning, etc. (except washing clothes), require water at a very much lower temperature than 212°. If, however,

water at a higher temperature is wanted, it can be supplied up to about 230° without the generation of steam, by heating it under pressure; this can be attained by having a close boiler fed from a cistern placed at the top of the house. For the preparation of preserves and some other cooking operations, such a system is most convenient.

One pound of coal should raise from fifty to sixty gallons of water from 45° to 212°, and, when raised, very little fuel is required to maintain it, in a properly-constructed boiler, at that temperature. The total amount of water, at such a temperature, used daily, in an ordinary middle-class house, does not exceed thirty or forty gallons, and, therefore, if the boiler were made so as to absorb as much heat as possible, the hot water used in an ordinary middle-class house, with a family of ten or twelve persons, ought not, with thorough economy, to consume more than one-sixth of a ton of coals in the year. Count Rumford shows in his treatise that 25 lbs. of bread ought to be baked with one pound of coal, and that 100 lbs. of meat should be cooked with 2¼ lbs. of coal. If, therefore, we fully utilized our fuel, it is clear that, in the preparation of our food and hot water for domestic purposes, ½ lb. of coal per head of the population ought to be a sufficient daily allowance, which would be equivalent to one-twelfth of a ton per annum, and in large households even less than that quantity ought to suffice. I do not suppose that we should ever attain to this minimum of consumption, but it is well to consider what the standard is, so that we may not rest satisfied till it has been much more nearly approached than hitherto.

Economy has, as I before observed, latterly been sought in combined apparatus. Where large numbers of persons have to be cooked for, and where, consequently, a carefully-constructed apparatus is always worked to its full extent, the results which have been obtained show a very moderate consumption of fuel; but the same apparatus, when used for smaller numbers of persons, gives results not favorable to economy.

The boilers in use in barracks, when I first took up the question, required from 16 ozs. to 20 ozs. of coal per head to supply water for breakfast and tea, and washing up, and to make soup for dinner for fifty or sixty men. The boilers I introduced would perform the same duty with from 3 to 4 ozs. of coal for each person cooked for, provided the number amounted to fifty or sixty persons. The ovens for roasting, which I introduced into barracks, would roast and bake with 1 oz. of coal for each person cooked for, when cooking for the full number for which the oven was designed, and for such numbers as 200 to 400 persons; smaller ovens would require 2 ozs. per head when cooking for 50 men. Of course, to produce these effects, great care was required.

Messrs. Benham introduced cooking apparatus which, when cooking for the full number of 300 soldiers, would perform the total daily

cooking and supply of hot water in barracks, with from two to three ounces of coal per person cooked for.

Captain Warren constructed an apparatus to boil, bake, steam, roast, and fry, and provide hot water, which, when cooking for about 100 men, required somewhere about 2¾ ozs. for each person cooked for, but, when cooking for forty men, required 6 oz. per head, and when cooking for sixteen men the average of several days amounted to 9 ozs. or 10 ozs. per man cooked for, but on one or two of these days the consumption did not exceed 5 ozs. for each person cooked for.

These apparatus supplied to the men all the cooking and hot water necessary. The results show what degree of economy has been reached in ordinary practice with soldiers, who are not proverbial for care, and what, therefore, should be the standard of economy to which we have a right to expect to attain. No doubt, private houses containing sixteen persons might require more hot water or more cooking, but according to these facts, as to ascertained consumption of fuel, the expenditure of fuel in the kitchen for a family consisting of sixteen persons might easily be reduced to 1½ or 2 tons per year, and in all these apparatus further elements of economy remain to be developed.

The conclusions, however, to which I have been led in my consideration of this question, are, that with these apparatus, and, indeed, with all kitchen-ranges in use, the waste of heat lies in the number of functions the fire has to perform. It must warm water, it must heat the oven, it must stew, and grill, or toast, and sometimes roast at the open fire, and each of these processes requires a different condition of heat. Hot water requires a temperature of 200° to 210°, a roasting-oven of about 450°, a baking-oven probably 350°; grilling is performed on a clear flame, the temperature of which is probably 1,300°. Now, when the fire is in an efficient condition to perform one of these functions, it is also in an efficient condition to perform the others, and, although, by means of dampers, it may be somewhat checked in the performance of its full functions in certain directions, there is no doubt that an enormous amount of heat is wasted through the agency of those parts which are not wanted to be in operation. When the oven is not wanted, it is affording a means for the heat to escape rapidly, especially if ventilated as a roasting-oven. The boiler is supplied with heat beyond its requirements, and generally abstracts a large quantity of spare heat, which passes off in the shape of steam. I assume that the cook closes the dampers in order, as far as possible, to limit the action of the fire when cooking is not going on, but in practice this is difficult to insure. With these combined apparatus, the fuel consumed will be in proportion to the various operations which the fire is arranged to perform, and not in proportion to the limited work required when only one or other of the operations is wanted. When, for instance, the fire is only wanted to heat water, a great waste of heat will be going on, from the heat passing off from the

oven, hot-plate, and front of the fire. For this reason, the combined apparatus can never be so economical in fuel as separate apparatus; while, however, apparatus of this class, if not very carefully worked, waste fuel, they, to some extent, save trouble to the cook.

I have already mentioned several points of detail where fuel could be saved in our kitchen-ranges, viz., by great attention to the close fitting of the ash-pit and fire-grate doors, the use of double covers to saucepans and boilers, the use of sand on the hot-plate to prevent the escape of so much heat from that part; and, beyond these, an important point in securing economy is the separation of those culinary processes which require different gradations of heat. The three main parts of the ordinary cooking apparatus are the oven for baking and roasting, and the boiler, and the hot-plate. If the boiler is to be of the form most effectual in saving fuel, the flame and gases from the fire should play under and round every part of it; the water should be kept at something under 212°, so that the gases, after leaving the boiler, may not enter the flue much above that temperature, and, inasmuch as that is a higher temperature than is necessary for the purpose of producing a sufficient draught in an ordinary chimney, the heat in these gases should be still further utilized. In the first place, they should be used to warm the water which will be required to replace what is drawn off from the boiler; and, in the second place, an economy can be obtained by employing the gases, which pass off into the chimney at a temperature above what is required for creating an efficient draught, to warm the air supplied to the fire for purposes of combustion. The experiments which I have made on the supply of warmed air to feed the fire have, unfortunately, not been worked out sufficiently to enable me to give them in a clear form with exact results; but an economy of from six to nine per cent. might be obtained from this source.

Then, as regards the oven. The baker's oven, of fire-brick, in which the fire is made inside the oven, and the whole heat retained in and reflected back from the sides and top and bottom, is a very economical instrument when in continual use. With iron ovens, attached to a kitchen range, the case is different. An oven which roasts requires a temperature of from 400° to 450° at least. Therefore, to maintain this temperature, the gases must pass off into the flue at a temperature even higher; when the oven is a roaster, a considerable volume of air is being continually passed through it to carry off the steam from the meat. This air, if admitted cold, as is the case with many ranges, acts so as to cool down the interior, and therefore additional fuel has to be consumed to counteract this cooling-down process. Now, however good may be the conducting power of the material used for ovens or boilers, a coating of soot diminishes the conducting power very rapidly, and consequently the temperature of the flue conveying heat to the oven will always exceed that of the inside of the oven. It is, there-

fore, of great importance to remove any causes which tend to lower the inside temperature. Hence it is desirable to utilize some of the heat which passes off, at above 450°, into the flue, for the purpose of raising the temperature of the air to be admitted into the oven. As a general rule, however, and except in some apparatus, under present arrangements all this heat is wasted, and it certainly cannot be utilized properly so long as one fire is retained to perform so many separate operations.

The hot-plate is the third important part of the modern close cooking-range. Count Rumford proposed that the top of a hot-plate should be covered with sand, and the sand cleared away only under the saucepans. In its present shape, the hot-plate wastes an enormous amount of heat. It is wasteful, because it radiates the heat largely; because the application of heat to the saucepans is only through the bottom of the saucepan, and the bottom of the saucepan is not always in immediate contact with the flame, but is frequently allowed to receive the heat through the medium of the cast-iron hot-plate, which is a very moderate conductor of heat. Just consider what the difference of effect is. The heat of the flame, if directly acting on the bottom of the saucepan, would be 1,200° Fahr., but, unless the hot-plate is red-hot, probably not above 450° will pass through, but the heat in the flue which heats the hot-plate will be at 1,200°, and the spare heat from the flame will be wasted up the chimney. The hot-plate should be dispensed with, if economy is to be made paramount, and charcoal burners substituted for it. Where gas is available, the hot-plate can be dispensed with without extra trouble to the cook. The gas-burners should be properly protected in sunken holes, with side of fire-clay, and the saucepans should be dropped into the holes, so that the full effect of the heat shall be concentrated on them and round their sides, and the gas should be only kept lighted so long as the operation to be performed is going on. It may be assumed that one pound of coal is equivalent to from 28 to 30 cubic feet of gas; hence, as permanent fuel, gas would not be economical; but the simplicity of its application makes it a very convenient fuel in cooking, and economy is obtained from its use, because the full effect of the combustion can be utilized as soon as the gas is lighted, the flame can be regulated to any required extent, and the gas be extinguished as soon as the required operation is performed.

I have endeavored to enumerate, briefly, the economical conditions which should regulate the consumption of fuel for domestic purposes. By economy it is meant that, while all necessary operations of warming and cooking continue to be performed, the fuel employed should be utilized to the utmost. In the kitchen, the daily consumption of fuel, in small establishments, should not exceed half a pound of coal for each person cooked for, and in large establishments the proportion should be smaller. In the consumption of fuel for warming, so many

conditions have to be considered that no standard can be laid down beyond the broad fact already stated—that one-sixth of the coal we commonly now use would suffice for all our requirements if it were properly utilized. I do not, however, anticipate that much progress will be made in economy, unless the price of coals should remain at a figure which will induce the householder to make himself thoroughly acquainted with the principles on which the apparatus for warming and cooking should be constructed and worked; for there is no apparatus which can be invented which will not depend, to a considerable extent, on the manner in which it is attended to.

The principal conditions which I have enumerated have long been known. There is an old saying in South Staffordshire, that "he who lives longest must carry coal farthest," and, acting on this, we have, year after year, simply wasted millions of tons of coal in our domestic fireplaces, because the coal was provided at a small cost, and we have had no thought for posterity.

George Stephenson once said, very happily, that coal represented the accumulated rays of the sun laid up in store in by-gone days. When this store is gone, the world will have lost the most convenient and economical means of generating heat. It is, therefore, a duty, which every man owes to posterity, to do his utmost to husband this great store.

I have endeavored to do my part by explaining the conditions which should govern the arrangements devised for regulating the consumption of fuel for domestic purposes. It remains for the public to insist on having these principles applied to the various apparatus which they adopt.—*Journal of the Society of Arts.*

ON THE HEREDITARY TRANSMISSION OF ACQUIRED PSYCHICAL HABITS.

By Dr. WILLIAM B. CARPENTER, LL. D., F. R. S.

PROCEEDING, now, to show that the tendency of modern Physiology is to prove the existence of a distinct *causal* relation between Physical changes in the Nervous System and definite modes of Mental action, it may be well for me to adduce, *in limine*, the positive evidence that *all* Mental activity is dependent on a Chemical reaction between the Blood and the Brain: for, although this is one of the best-established facts in Physiology, it is, I believe, taken very little account of by Metaphysicians.—The Brain is supplied with Blood by four Arterial trunks, which enter the cranial cavity at no great distance from one another, and then unite into the "Circle of Willis;"

from which are given off the various branches that distribute arterial blood to every part of the brain-substance. After traversing this, the blood returns by the Veins, greatly altered in its chemical composition; especially as regards the loss of free oxygen, and its replacement by various oxy-compounds of carbon, hydrogen, phosphorus, etc., that have been formed by a process analogous to combustion. Now, if one, two, or three of the Arterial trunks be tied, the total supply of blood to the Brain is diminished; but, in virtue of the "Circle of Willis," no part is entirely deprived of blood; and the functional activity of the Brain is still maintained. If, however, the *fourth* artery is compressed so as to prevent the passage of blood, there is an *immediate* and *complete* suspension of activity; the animal becoming as unconscious as if it had been stunned by a severe blow, but recovering as soon as the blood is again allowed to flow through the artery. In fact, the "stunned" state produced by a blow on the head is *not directly* dependent upon the effect of that blow on the Brain, which may have sustained no *perceptible* injury whatever; the state of insensibility being due to the paralysis of the Heart and suspension of the Circulation, induced by the "shock:" and the like paralysis with the same result may be produced by a blow on the Epigastrium (acting on the great "solar plexus" of nerves), or some overpowering Mental emotion.—Again, there is a curious affection termed Hysteric Coma, which consists in the sudden supervention of complete insensibility, and the equally sudden and complete return of conscious intelligence, without any other indication of Brain-disorder. The insensibility may come on while the patient is talking, so as to interrupt the utterance of a sentence; and, the moment that it passes off, the series of words is taken up and completed, without the patient being aware that it has been interrupted. With our present improved knowledge of the action of the "vaso-motor" system of Nerves in producing local contractions of the Arteries, and of its liability to be influenced by those Emotional irregularities in which Hysteria essentially consists, we can scarcely doubt that this affection is due to a temporary disturbance of the Circulation through that agency.—Further, if the Blood transmitted to the Brain, though not deficient in quantity, be depraved in *quality* by the want of Oxygen and the accumulation of Carbonic acid (as happens in Asphyxia), there is a gradually increasing torpor of the Mental Faculties, ending in complete insensibility.

Thus the dependence of Mental activity of even the most elementary kind, upon the Physical changes kept up by the circulation of oxygenated Blood through the Brain, can be shown experientially to be just as direct and immediate as is the dependence of the Electric activity of a Galvanic battery upon the analogous changes taking place between its Metals and its exciting Liquid.—If we say that Electricity is the *product* of Chemical change in the one case, I see

not how we can refuse to regard Thought as the *product* of Chemical change in the other; nor (in the view that all the Forces of Nature are simply expressions of Mind) do I see that we need entertain any repugnance to such a view. I do not say that it *explains* any Mental phenomenon. No sound Physicist would say that he can "explain" how it is that Electricity is generated by Chemical change; but he knows that such a relation of cause and effect exists between the two orders of phenomena, that every Chemical change is accompanied by an Electric disturbance; so that, whenever he witnesses Electric disturbance, he looks with assurance for some Chemical change as its Physical Cause. And in precisely the same sense, and in no other, I affirm that the Physiologist *must* regard some change in the Nervous substance of the Brain as the immediate Physical cause of all *automatic* Mental action. If this be admitted of Sensational consciousness (and how can it be denied?), we can scarcely help admitting it of Emotional; and, if of Emotional, why not of Ideational?

There is no part of our purely Physical activity, the relation of which to Physical conditions is more obvious and more intimate, than that *Reproduction of past states of Consciousness*, which—when supplemented by the *recognition* of them as having been formerly experienced—we call *Memory*. It is now very generally accepted by Physiologists as (to say the least) a *probable* doctrine, that *any* Idea which has once passed through the Mind, *may* be thus reproduced, at however long an interval, through the instrumentality of Suggestive action; the recurrence of any other state of Consciousness with which that Idea was originally linked by Association, being adequate to awaken *it* also from its dormant or latent condition, and to bring it within the "sphere of consciousness." And as our Ideas are thus linked in "trains" or "series," which further inosculate with each other like the branch-lines of a railway or the ramifications of an artery, so, it is considered, an Idea which has been "hidden in the obscure recesses of the mind" for years—perhaps for a lifetime—and which seems to have completely faded out of the *conscious* Memory (having never either recurred Automatically, or been found capable of recall by Volitional Recollection, or been recognized as a past experience when again brought before the mind), may be reproduced, as by the touching of a spring, through a nexus of Suggestions, which we can sometimes trace out continuously, but of which it does not seem necessary that all the intermediate steps should fall within our cognizance. Such a "reproduction" not unfrequently occurs when persons, revisiting certain scenes of their childhood, have found the renewal of the Sensorial impressions of *places* bring vividly back to their minds the remembrance of *events* which had occurred in connection with them; and which had not only been long forgotten by themselves, but, if narrated to them by others, would not have been recognized by them as having ever formed part of their own experience.

And it is not a little significant that the basis of such Memories appears capable of being laid at a very early period of life; as in the two following cases, of which the first is recorded by Dr. Abercrombie, while the second was mentioned to me by the subject of it:

"A lady, in the last stage of chronic disease, was carried from London to a lodging in the country. There her infant daughter was taken to visit her, and, after a short interview, carried back to town. The lady died a few days after, and the daughter grew up without any recollection of her mother, till she was of mature age. At this time she happened to be taken into the room in which her mother died, without knowing it to have been so. She started on entering it, and, when a friend who was with her asked the cause of her agitation, replied, 'I have a distinct impression of having been in this room before, and that a lady who lay in that corner, and seemed very ill, leaned over me and wept.'"—(*Inquiries concerning the Intellectual Powers*, fifth edition, p. 120.)

"Several years ago, the Rev. S. Hansard, now Rector of Bethnal Green, was doing clerical duty for a time at Hurstmonceaux, in Sussex; and, while there, he one day went over with a party of friends to Pevensey Castle, which he did not remember to have ever previously visited. As he approached the gate-way, he became conscious of a very vivid impression of having seen it before; and he 'seemed to himself to see,' not only the gate-way itself, but donkeys beneath the arch, and people on the top of it. His conviction that he must have visited the Castle on some former occasion, although he had neither the slightest remembrance of such a visit, nor any knowledge of having ever been in the neighborhood previously to his residence at Hurstmonceaux, made him inquire from his mother if she could throw any light on the matter. She at once informed him that being in that part of the country when he was about *eighteen months* old, she had gone over with a large party, and had taken him in the pannier of a donkey; that the elders of the party, having brought lunch with them, had eaten it on the roof of the gate-way, where they would have been seen from below, while he had been left on the ground with the attendants and donkeys.—This case is remarkable for the vividness of the Sensorial impression (it may be worth mentioning that Mr. Hansard has a decidedly artistic temperament), and for the reproduction of details which were not likely to have been brought up in conversation, even if the subject of them had happened to hear the visit mentioned as an event of his childhood; and of such mention he has no remembrance whatever."

Now, there is very strong reason to believe that what is described as a storing-up of Ideas in the Memory is the Psychological expression of Physical changes in the Cerebrum, by which Ideational states are permanently registered or recorded; so that the "traces" left by them, although remaining so long outside the "sphere of consciousness" as to have *seemed* non-existent, may be revived again in full vividness under certain special conditions—just as the invisible impression left upon the sensitive paper of the Photographer is "developed" into a picture by the application of particular chemical substances. It must be freely admitted that we have at present no certain knowledge of the precise mode in which this record is effected; but, looking at the manner in which the Sensori-motor apparatus, which

is the instrument of our *bodily* activity, shapes itself to the mode in which it is habitually exercised, we seem justined in assuming that the same thing is true of the Cerebrum, which is the instrument of our *mental* activity. For in no other way does it seem possible to account for the fact of very frequent occurrence, and noticed in a previous paper, that the presence of a Fever-poison in the blood—perverting the normal activity of the Cerebrum so as to produce *Delirium*—brings within the "sphere of consciousness" the "traces" of experiences long since past, of which, in the ordinary condition, there was no remembrance whatever.

The same occurrence has been noticed as a consequence of accidental blows on the head; though these more commonly occasion the *loss* than the *recovery* of a language. The following case of this kind is mentioned by Dr. Abercrombie, as having occurred in St. Thomas's Hospital:

> "A man who had been in a state of stupor consequent upon an injury of the head, on his partial recovery spoke a language which nobody in the hospital understood, but which was soon ascertained to be Welsh. It was then discovered that he had been thirty years absent from Wales, and that, before the accident, he had entirely forgotten his native language. On his perfect recovery, *he completely forgot his Welsh again*, and recovered the English language." —(*Op. cit.*, p. 148.)

It seems perfectly clear, then, that, under what we cannot but term purely *Material* conditions, strictly *Mental* phenomena present themselves. It is common to the whole series of cases, that the Automatic play of the "Mechanism of Thought" does that which Volition is unable to effect. Whether it be the *toxic* condition of the Blood, or the simple excitement of the Cerebral Circulation generally, or the special direction of Blood to a particular part of the Brain, it is beyond our present power to tell; but, as *all* Brain-change is (like the action of any other mechanism) the manifestation of Force, the production of these *unusual* Mental phenomena, by the instrumentality of an unusual reaction between the Blood and the Brain-substance, is no more difficult of comprehension than that of *ordinary* forms of Psychical activity, which we have seen reason to regard as the results of the translation (so to speak) of one form of Force into another.

The intimacy of the relation between the Psychical phenomena of Memory and Physical conditions of the Brain is further shown, by the effect of Fatigue and the impaired Nutrition of Old Age in *weakening* the Memory, and of disease and Injury of the Brain in *impairing* or *destroying* it. Every one is conscious of the difference in the activity of the reproductive faculty in which Memory consists, according as his mind is "fresh," or his head feels "tired." The latter state, in which the Automatic activity and the directing power of the Will are alike reduced, is clearly dependent, like the feeling of muscular fatigue, on the deterioration of the Organ, or of the Blood, or of both

combined, which results from the prolonged exercise of it: and it is especially in our inability to *recollect* something which we *wish* to call to mind, that this failure of power shows itself. An interval of repose completely restores the power, obviously (to the mind of the Physiologist) by the renovation of the worn-out Brain-tissue, and by the purification of the Blood that has become charged with the products of its "waste."—The impairment of the Memory in Old Age commonly shows itself in regard to *new* impressions; those of the earlier period of life not only remaining in full distinctness, but even, it would seem, *increasing* in vividness, from the fact that the Ego is not distracted from attending to them by the continual influx of impressions produced by passing events. The extraordinary persistence of early impressions, when the Mind seems almost to have ceased to register new ones, is in remarkable accordance with the Law of Nutrition referred to in a previous paper. It is when the Brain is *growing*, that the *direction* of its structure can be most strongly and persistently given to it. Thus the Habits of Thought come to be formed, and those Nerve-tracks laid down which (as the Physiologist believes) constitute the Mechanism of Association, by the time that the Brain has reached its maturity; and the Nutrition of the organ continues to keep up the same mechanism, in accordance with the demands upon its activity, so long as it is being called into use. Further, during the entire period of vigorous Manhood, the Brain, like the Muscles, may be taking on some additional growth, either as a whole, or in special parts; new tissue being developed and kept up by the nutritive process, in accordance with the modes of action to which the Organ is trained. And in this manner a store of "impressions" or "traces" is accumulated, which may be brought within the "sphere of consciousness" whenever the right suggesting-strings are touched. But, as the Nutritive activity diminishes, the "waste" becomes more rapid than the renovation; and it would seem that, while (to use a Commercial analogy) the "old-established houses" keep their ground, those later firms whose basis is less secure, are the first to crumble away—the Nutritive activity, which yet suffices to maintain the *original* structure, not being capable of keeping the subsequent additions to it in working order. This *earlier* degeneration of *later*-formed structures is a general fact perfectly familiar to the Physiologist.

The effects of Disease and Injury on the Memory are so marvellous and diverse, that only a very general indication of them can be here given. Cases are very common, in which the form of impairment just spoken of as characteristic of Old Age shows itself to a yet greater extent; the Brain being so disordered by attacks of Apoplexy or Epilepsy (for example), that it seems altogether incapable of retaining any *new* impressions, so that the patient does not remember any thing that passes from day to day; while the impressions of events which happened *long before* the commencement of his malady recur with

greater vividness than ever. The Memory of *particular classes of Ideas* is frequently destroyed; that, for example, of a certain Language, or of some other branch of Knowledge, or of the patient's domestic or social relations. Thus a case was recorded by Dr. Beattie, of a gentleman, who, after a blow on the head, found that he had lost his knowledge of Greek, but did not appear to have suffered in any other way. A similar case has been recently communicated to me, in which a lad, who lay for three days insensible, in consequence of a severe blow on the head, found himself, on recovering, to have lost all the Music he had learned, though nothing else had been thus "knocked out" of him. Again, Dr. Abercrombie relates a curious case, on the authority of an eminent medical friend, in which a surgeon who suffered an injury of his head by a fall from his horse, on recovering from his insensibility gave minute directions in regard to his own treatment, but was found to have lost all remembrance of having a wife and children; and this did not return until the third day. Similar losses of particular Languages, and other kinds of acquired knowledge, have been noted as the results of Fevers.

One of the most remarkable results of recent Pathological research has been, the discovery of the dependence of the condition termed *Aphasia*, or "loss of memory of words," upon malnutrition of a certain part of the Cerebrum; and the tracing of this malnutrition back to an interruption in the supply of Blood. In this curious Mental infirmity (which often begins to show itself before there is any other evidence of Cerebral disorder, but which is now recognized as a most serious indication of impending mischief), the subject either forgets the words he wants for expressing his ideas, or he uses *inappropriate* words in their place. It is obvious that he *knows* what he wants to express, but cannot recall the words in which to convey that knowledge to others. There is no paralysis of speech, for his articulation is quite unaffected; so that he can repeat the words he wants, if they are suggested to him by others. In a case formerly under my observation, the Aphasia went on gradually but very slowly increasing for three or four years; showing itself at first as to only a few out-of-the-way words, but gradually increasing until no intelligible language seemed to be left, except that of swearing, which came forth in a torrent when any restraint was put on the patient's bodily activity, which continued very energetic until near the close of life. In another case recently mentioned to me by a medical friend, who was a near connection of the patient, the disease ran its course in a few months. Cases of this kind almost invariably terminate in Apoplexy.—Now, it may be said that we have here only the evidence of *synchronous* disease of the Brain and disorder of the Mind; so that the *dependence* of the latter upon the former is not made out. But the very curious discovery was made a few years ago, by Dr. J. Hughlings Jackson, that the locally-impaired nutrition of the Brain in these cases is usu-

ally attributable to "embolism" of the middle meningeal artery, whereby the passage of blood through it is greatly impeded; this "embolism" consisting in the plugging of the artery by a fibrinous clot brought from the heart, where it has been produced by valvular disease. In the second of the cases just referred to, the usual brain-lesion having been found, and the middle meningeal artery having been examined, the *fons et origo* of the mischief was found to be, not "embolism," but a morbid deposit on the inner wall of the artery, producing a corresponding obstruction to the circulation. Looking, then, to the fact that *immediate* cessation of Mental activity is distinctly and unmistakably produced by the *entire* suspension of Blood-circulation through the Brain, how can the Physiologist refuse to recognize, in this *local* reduction of the Circulation, the Physical cause of that *limited* reduction of Psychical activity which so distinctly follows it?

But further, this singular fact, taken in connection with the recent great extension of our knowledge as to the local alterations in the calibre of the Arteries, which are produced through the "Vaso-motor" system of Nerves, obviously points to the probability that the *limited* but *transient* lapses of Memory just alluded to are due to a local reduction of the blood-supply in the part of the Cerebrum which ministers to the lost function; and that the *sudden* recovery which sometimes occurs is the result of the renewal of the normal circulation, through the giving way of the impacted clot, or the yielding of the spasmodically-constricted arterial wall.

Thus Dr. Rush, of Philadelphia, was acquainted with a person of considerable attainments, who, on recovering from a fever, was found to have lost all his acquired knowledge. When his health was restored, he began to apply himself to the Latin Grammar; and, while, one day, making *a strong effort* to recollect a part of his lesson, *the whole of his lost impressions suddenly returned to his remembrance*, so that he found himself at once in possession of all his former acquirements.—The like sudden restoration, after an equally sudden loss, occurred in another case in which all acquired knowledge was lost for *a whole year;* and in both the loss and the recovery there was clear evidence of strong *Emotional* excitement, which is well known to the Physiologist to have a most powerful control over the calibre of the Blood-vessels.

There is another class of familiar phenomena, which affords strong evidence of the dependence of the *recording process* upon Nutritive changes in the Brain. Every one is aware that what is rapidly learned —that is, merely committed to Memory—is very commonly forgotten as quickly, "one set of ideas driving out another." That thorough apprehension of what is learned, on the other hand, by which it is made (as it were) part of the Mental fabric, is a much slower process. The difference between the two is expressed by the colloquial term

"cramming," as distinguished from "learning;" the analogy being obvious to the overloading the stomach with a mass of food too great to be digested and assimilated within a given time, so that a large part of it passes *out of* the body without having been applied to any good purpose *in* it. A part of this difference obviously consists in the formation of *Mental Associations* between the newly-acquired knowledge and that previously possessed; so that the new ideas become linked on with the old by "suggesting" chains. Such is especially the case, when we are applying ourselves to the study of any branch of knowledge, with the view of permanently mastering it; and here the element of *Time* is found practically to be very important. Thus, it is recorded of the late Lord St. Leonard's that, having (as Sir Edward Sugden) been asked by Sir T. F. Buxton what was the secret of his success, his answer was: "I resolved, when beginning to read Law, to make every thing I acquired *perfectly my own*, and never to go to a second thing till I had entirely accomplished the first. Many of my competitors read as much in a day as I read in a week; but, at the end of twelve months, my knowledge was as fresh as on the day it was acquired, while theirs had glided away from their recollection."—(*Memoirs of Sir T. F. Buxton*, chap. xxiv.) —In this Assimilating process, it is obvious that the new knowledge is (as it were) turned over and over in the Mind, and viewed in all its aspects; so that, by its coming to be not merely an *addition* to the old, but to *interpenetrate* it, the old can scrarcely be brought into the "sphere of consciousness," without bringing the new with it. But, from the considerations already adduced, it seems almost beyond doubt that the formation of this Associative *nexus* expresses itself in the Physical structure of the Brain, so as to create a mechanism whereby it is perpetuated so long as the Nutrition of the organ is normally maintained.

Another class of phenomena, now to be considered, seems to afford even more direct and cogent evidence of the dependence of Memory, in its simplest exercise, upon a *registering* process, that consists in some Nutritive modification of the Brain-tissue. In what we call "learning by heart"—which should be rather called learning by Sense, instead of by Mind—we try to imprint on our Memory a certain sequence of words, numbers, musical notes, or the like; the reproduction of these being mainly dependent upon the association of each *item* with that which follows it, so that the utterance of the former, or the picture of it in "the mind's eye," *suggests* the next. We see this plainly enough when children are set to learn a piece of poetry of which their minds do not take in the meaning; for the *rhythm* here affords a great help to the suggestive action; and nothing is more common than to hear words or clauses (transferred, perhaps, from some other part of the poem) *substituted for the right ones*, which are not only inappropriate but absolutely absurd in the lines as uttered.

So, again, if the child is at fault, he does not think of the *meaning* of the sentence, and of what is wanted to complete it; but "tries back" over the preceding words, that their *sound* may suggest that of the word he desiderates. So there are older persons, with whom the *pictured* remembrance of the words and phrases is more suggestive; as in a case to be presently cited.—Now, in these instances, it is a familiar fact that what is thus learned but once, however perfectly, soon "goes out of the head," being only fixed there by continual repetition; and, as the Memory we are now considering is rather *Sensorial* than *Ideational*, this fact is confirmatory of the doctrine that seems probable on other grounds, of the superior (if not the exclusive) persistence of the latter. We seem distinctly able to trace the action of the *recording process* in this elementary form of Memory, in the help given in the "learning by heart" of a task, by repeating it the last thing at night; for every school-boy, who has to commit to memory fifty lines of Virgil, knows very well that, if he can "say them to himself," even slowly and bunglingly, just before going to sleep, he will be able to recite them much more fluently in the morning. The Physiologist sees here an obvious indication that the *recording process* has gone on without interruption by new impressions on the Sensorium, so that there has been *time* for the *fixation* of the last by Nutritive change. We have, indeed, a remarkable *converse* phenomenon, in the rapid fading away of a Dream, which, at the moment of waking, we can reproduce with extraordinary vividness; for the "trace" left by its details is soon obliterated by the new and stronger impressions made on our waking Consciousness, so that, a few hours afterward, we are often unable to revive more than the general outline of the Dream—and perhaps not even that, unless we have told it to another when it was fresh in our minds, of which act a "trace" would be left.

There are two classes of persons who are professionally called upon for great *temporary* exercises of Memory, viz., Dramatic Performers and Barristers. An actor, when about to perform a new "part," not only commits it to memory, but "studies" it, so as to make it part of himself; and all really *great* actors identify themselves for the time with the characters they are performing. When a "part" has once been thoroughly mastered, the performer is usually able to go through it, even after a long interval, with very little previous preparation. But an actor is sometimes called upon to take a new "part" at very short notice; he then simply "learns it by heart," and speedily forgets it. A case of this kind is cited by Dr. Abercrombie, as having been the experience of a distinguished actor, on being called on to prepare himself in a long and difficult part, at a few hours' notice, in consequence of the illness of another performer. He acquired it in a very short time, and went through it with perfect accuracy; but immediately after the performance forgot it to such a degree that, although he performed the character for several days in succession, he was obliged

every day to prepare it anew—not having time to go through the process of "studying" it, to which Mrs. Siddons used to give weeks or even months. When questioned respecting the mental process which he employed the first time he performed the part, he said that he entirely lost sight of the audience, and seemed to have nothing before him but the pages of the book from which he had learned it; and that, if any thing had occurred to interrupt this illusion, he should have instantly stopped.—(*Inquiry into the Intellectual Powers*, fifth edition, p. 103.)

In the case of Barristers, who are called upon to "get up" the "briefs" which are supplied to them, to master the facts, to apply to them the principles of Law, and to present them in the Court in the form which they deem most advantageous to the "cause" they have undertaken to plead, the very highest faculties of mind are called into active exercise; but, in consequence, it would seem, of the want of previous connection with the "case" (of which they know nothing but what is set down in their "brief"), and of the complete cessation of that connection as soon as the decision has been given, they very commonly "forget all about it" so soon as they have transferred their Attention to their next brief. A curious instance of this kind was mentioned to the writer a few years ago by an eminent Barrister (since elevated to the Judicial Bench), whose great scientific attainments led to his being frequently employed in Patent-cases. A "heavy" case of this kind was placed in his hands, and he was reminded of having been engaged by the same parties in the same "case" when it had been first brought to trial about a year previously. He had not the slightest remembrance of its having ever been before him; none of the particulars of it seemed familiar to him; and he was only convinced that he really *had* taken part in the previous trial by finding the record of his engagement in his Fee-book. Even when he came to "get up" the case again, no remembrance of his former attention to it came within his "sphere of consciousness."

It seems, then, to admit of question whether *every thing* that passes through our Minds thus leaves its impress on their Material instrument; and whether a somewhat too extensive generalization has not been erected on a rather limited basis. For the doctrine of the indelibility of Memory rests on the spontaneous revival, under circumstances indicative of some change in the Physical condition of the Brain, of the long-dormant "traces" left by such former impressions as are referable to one or other of the three following categories: 1. States of Consciousness as to places, persons, language, etc., which were *habitual* with us in early life, and which were, therefore, likely to have directed the *growth* of the Brain; 2. Modes of Thought in which the formation of Associations largely participates, and which are likely to have modified the course of its *maintenance* by Nutrition after the attainment of maturity; or 3. Single Experiences of peculiar force and vividness, such as are likely to have left very decided "traces," although the

circumstances of their formation were so unusual as to keep them out of ordinary associational remembrance. Thus a remarkable case is mentioned by Dr. Abercombie ("Intellectual Powers," fifth edition, p. 149) of a boy, who, at the age of four years, underwent the operation of trepanning, apparently in a state of perfect stupor, and who, after his recovery, retained no recollection either of the accident by which his skull was fractured, or of the operation, yet who, at the age of fifteen, during the delirium of fever, gave his mother an account of the operation and of the persons who were present at it, with a correct description of their dress, and other minute particulars of which it was scarcely possible that he could have acquired the knowledge from verbal information. Here it would seem that all the Mental power the patient then had must have been concentrated upon the impressions made upon his Sensorium, which were thus indelibly branded (as it were) upon his Organism; but that these "traces," being soon covered up by those resulting from the new experiences of restored activity, remained outside the "sphere of consciousness" until revived by a Physical change which reproduced the images of the objects that had left them.

The direct causal relation of Physical conditions to Mental states may be made still more clear by following out into some detail the phenomena of that peculiar form of Intoxication which is produced by *Hashish*—a preparation of Indian hemp used in the Levant for the purpose of inducing what is termed the *fantasia*. The action of this drug was very carefully studied some years ago by M. Moreau, Physician to the Bicêtre, who had given great attention to the Psychology of Insanity, and whose special object was to throw light upon that subject by experimenting upon what he termed its artificial production. His treatise, "Du Hachisch, et de l'Aliénation Mentale" (Paris, 1845), is one which deserves the attentive study of such as desire to base their Psychology upon a comprehensive survey of facts.

One of the first appreciable effects of the *Hashish*, as of other Intoxicating agents, is the gradual weakening of that power of *Volitionally* controlling and directing the current of thought, the possession of which characterizes the vigorous mind. The individual feels himself incapable of fixing his attention upon any subject; the continuity of his thoughts being continually drawn off by a succession of disconnected ideas, which force themselves (as it were) into his mind, without his being able in the least to trace their origin. These speedily engross his attention, and present themselves in strange combinations, so as to produce the most impossible and fantastic creations. By a strong effort of the Will, however, the original thread of the ideas may still be recovered, and the interlopers may be driven away; their remembrance, however, being preserved, like that of a dream recalling events long since past. These lucid intervals progressively become shorter in

duration, and can be less frequently procured by a voluntary effort; for the internal tempest becomes more violent, the torrents of disconnected ideas are so powerful as completely to arrest the attention, and the mind is gradually withdrawn altogether from the contemplation of external realities, being conscious only of its own internal workings. There is always preserved, however, a much greater amount of "self-consciousness" than exists in ordinary Dreaming; the condition rather corresponding with that in which the sleeper knows that he dreams, and, if his dream be agreeable, makes an effort to prolong it, being conscious of a fear lest he should by awaking cause the dissipation of the pleasant illusion.

It is another characteristic of the action of *hashish* that the succession of ideas has *at first* less of incoherence than in ordinary Dreaming, and the ideal events do not so far depart from possible realities; the disorder of the mind being at first manifested in errors of sense, in false convictions, or in the predominance of one or more extravagant ideas. These ideas and convictions are generally not altogether of an imaginary character, but are rather *suggested* by external impressions, these impressions being erroneously interpreted by the perceptive faculties, and giving origin, therefore, to fallacious notions of the objects which excited them. It is in that more advanced stage of the "fantasia' which immediately precedes the complete withdrawal of the mind from external things, and in which the self-consciousness and power of the Will are weakened, that this perverted impressibility becomes most remarkable, more especially as the general excitement of the Feelings causes the erroneous notions to have a powerful effect in arousing them.

"We become," says M. Moreau, "the sport of impressions of the most opposite kind; the continuity of our ideas may be broken by the slightest cause. We are turned, to use a common expression, by every wind. By a word or a gesture our thoughts may be successively directed to a multitude of different subjects with a rapidity and a lucidity which are truly marvellous. The mind becomes possessed with a feeling of pride corresponding with the exaltation of its faculties, of whose increase in energy and power it becomes conscious. It will be entirely dependent on the circumstances in which we are placed, the objects which strike our eyes, the words which fall on our ears, whether the most lively sentiments of gayety or of sadness shall be produced, or passions of the most opposite character shall be excited, sometimes with extraordinary violence; for irritation shall rapidly pass into rage, dislike to hatred and desire of vengeance, and the calmest affection to the most transporting passion. Fear becomes terror, courage is developed into rashness, which nothing checks, and which seems not to be conscious of danger, and the most unfounded doubt or suspicion becomes a certainty. *The Mind has a tendency to exaggerate every thing;* and the slightest impulse carries it along. Those who make use of the *Hashish* in the East, when they wish to give themselves up to the intoxication of the *fantasia*, take care to withdraw themselves from every thing which could give to their delirium a tendency to melancholy, or excite in them any thing else than feelings of pleasurable enjoyment; but they profit by all the means which the dissolute manners of the East place at their disposal."

The disturbance of the Perceptive Faculties is remarkably shown in regard to Time and Space. Minutes seem hours, and hours are prolonged into years; and at last all idea of Time seems obliterated, and the past and present are confounded together. M. Moreau mentions as an illustration, that on one evening he was traversing the passage of the Opera when under the influence of a moderate dose of *Hashish*. He had made but a few steps, when it seemed to him as if he had been there two or three hours; and, as he advanced, the passage appeared to him interminable, its extremity receding as he pressed forward. But he gives another more remarkable instance. In walking along the Boulevards, he has frequently seen persons and things at a certain distance presenting the same aspect as if he had viewed them through the large end of an opera-glass—that is, diminished in apparent size, and therefore suggesting the idea of increased distance. This erroneous perception of Space is one of the effects of the *Amanita muscaria*, an intoxicating Fungus used by the Tartars; a person under its influence being said to take a jump or a stride sufficient to clear the trunk of a tree when he wishes only to step over a straw or a small stick. Such erroneous perceptions are common enough among Lunatics, and become the foundations of fixed illusions; while in the person intoxicated by *Hashish* there is still a certain consciousness of their deceptive character.

Though all the Senses appear to be peculiarly impressible in this condition, yet that of Hearing seems the one through which the greatest influence may be exerted upon the Mind, especially through the medium of musical sounds. The celebrated artist, M. Théodore Gaultier, describes himself as hearing sounds from colors, which produced undulations that were perfectly distinct to him. But he goes on to say that the slightest deep sound produced the effect of rolling thunder; his own voice seemed so tremendous to him that he did not dare to speak out for fear of throwing down the walls, or of himself bursting like a bomb; more than five hundred clocks seemed to be striking the hour with a variety of tones, etc., etc. Of course, those individuals who have a natural or an acquired "musical ear" are the most likely to be influenced by the concord or succession of sweet sounds; and in such the simplest music of the commonest instrument, or even an air sung by a voice in a mediocre style, shall excite the strongest emotions of joy or melancholy, according as the air is cheerful or plaintive; the mental excitement being communicated to the body, and being accompanied with muscular movements of a semi-convulsive nature. This influence of music is not merely sensual, but depends, like that of other external impressions, upon the associations which it excites, and upon the habitual disposition to connect it with the play of the Imaginative faculties.

It is seldom that the excitement produced by the Hashish fixes itself upon any particular train of Ideas, and gives rise to a settled

delusion; for in general one set of ideas chases another so rapidly, that there is not time for either of them to engross the attention of the intellect; more especially since (as already remarked) there is usually such a degree of self-consciousness preserved throughout, as prevents the individual from entirely yielding himself up to the suggestions of his ideal faculties. M. Moreau mentions, however, that on one occasion, having taken an overdose, and being sensible of unusual effects, he thought himself poisoned by the friend who had administered it, and persisted in this idea in spite of every proof to the contrary—until it gave way to another, namely, that he was dead, and was about to be buried; his self-consciousness, however, being yet so far preserved that he believed his body only to be defunct, his soul having quitted it. But when this is altogether suspended, as it seems to be by a larger dose, the erroneous ideas become transformed into convictions, taking full possession of the mind; although sudden gleams of common-sense burst through the mists of the imagination, and show the illusive nature of the pictures which the "Internal Senses" have impressed on the Sensorium. All this—as every one knows, who has made the phenomena of Insanity his study—has its exact representation in the different stages of Mental Derangement; the illusive ideas and erroneous convictions being in the first instance capable of being dissipated by a strong effort of the Will, gradually exerting a stronger and stronger influence on the general current of Thought, and at last acquiring such complete mastery over it that the Reason cannot be called into effective operation for the correction of the perverted Ideas.

Here, then, we have an extraordinary *exaltation* of the Automatic action of the Brain, manifesting itself in the rapidity and intensity of the current of Thought; while the controlling power of the Will is not only relatively, but *absolutely* reduced. And this modification of the normal form of mental activity is clearly referable to the perversion of the normal action of the Blood upon the Brain, which is due to the introduction of a new Physical agent into the former. The production of errors of Perception, arising from the tendency to *magnification* of the impressions actually made on the senses, is a peculiarly interesting feature of this perversion; which is clearly a *mental* misinterpretation, not at all corresponding to the mere double vision of the drunken man, which is an error of *sense* arising from the temporary want of adjustment of the axes of the eyes. And with this magnification there is connected a sentiment of *happiness* which attends all the operations of the mind.

"It is really *happiness*," says M. Moreau, "which is produced by the Hashish; and by this I imply an enjoyment entirely Moral, and by no means sensual, as we might be induced to suppose. This is surely a very curious circumstance, and some remarkable inferences might be drawn from it; this, for instance, among others—that every feeling of joy and gladness, even when the

cause of it is exclusively moral—that those enjoyments which are least connected with material objects, the most spiritual, the most ideal—may be nothing else than sensations purely physical, developed in the interior of the system, as are those procured by the Hashish. At least, so far as relates to that of which we are internally conscious, there is no distinction between these two orders of sensations, in spite of the diversity in the causes to which they are due; for the Hashish-eater is happy, not like the gourmand or the famished man when satisfying his appetite, or the voluptuary in gratifying his amative desires; but like him who hears tidings which fill him with joy, like the miser counting his treasures, the gambler who is successful at play, or the ambitious man who is intoxicated with success."

Most persons will be able to recall analogous states of exhilaration, and the reverse condition of depression, in themselves; the former being characterized by a feeling of general well-being, a sentiment of pleasure in the use of all the bodily and mental powers, and a disposition to look with enjoyment upon the present, and with hope to the future; while in the latter state there is a feeling of general but indefinable discomfort. Every exertion, whether Mental or Bodily, is felt as a burden; the present is wearisome, and the future is gloomy. These, like all other phases of Human Nature, are faithfully portrayed by Shakespeare. Thus *Romeo* gives expression to the feelings inspired by the first state:

> "My bosom's lord sits lightly in his throne;
> And, all this day, an unaccustomed spirit
> Lifts me above the ground with cheerful thoughts."
> (*Romeo and Juliet*, V., 1.)

While the reverse state is delineated by *Hamlet* in his familiar soliloquy:

"I have of late—but wherefore I know not—lost all my mirth, foregone all custom of exercises; and, indeed, it goes so heavily with my disposition, that this goodly frame, the earth, seems to me a sterile promontory; this most excellent canopy, the air, look you—this brave o'erhanging firmament, this majestic roof fretted with golden fire, why it appears no other thing to me than a foul and pestilent congregation of vapors."—(*Hamlet*, II., 2.)

In the conditions here referred to, the same feelings of pleasure and discomfort attend *all* the operations of the mind—the merely Sensational and the Intellectual. In the state of exhilaration, we feel a gratification from sensations which at other times pass unnoticed, while those which are usually pleasurable are remarkably enhanced; and in like manner, the trains of Ideas which are started being generally attended with similar agreeable feelings, we are said to be under the influence of the pleasurable or elevating Emotions. On the other hand, in the state of depression we feel an indescribable discomfort from the very sensations which before produced the liveliest gratification; and the thoughts of the past, the present, and the future,

which we before dwelt on with delight, now excite no feelings but those of pain, or at best of *insouciance.*

Now, there are many persons in whom these opposite Emotional states are induced by Meteorological conditions; the one by a dry, clear, bright atmosphere; the other by that close, damp, "muggy" state of the air, which seems to lay a "wet blanket" upon all their enjoyment, both bodily and mental. And precisely the same depressing influence is often experienced from deficient action of the liver, causing an accumulation of the materials of bile in the blood; and it is just as apparent to the Physician that the elimination of these by appropriate remedies, so as to restore the Blood to its normal purity, thereby removes the Moral *depression*, as it is that the introduction of a minute quantity of Hashish into the Blood produces a Moral *exaltation.*

In these days of eager competition, again, it is extremely common for a psychical state to be induced by the overtasking of the Brain, which every intelligent medical practitioner recognizes as essentially physical in its origin, but which yet manifests itself chiefly in moral, and not unfrequently, also, in intellectual perversion. The excess of activity is followed, as its natural result, by a state of depression; in which the subject of it looks at every thing, past, present, and future, in a gloomy light, as through a darkened glass. His whole life has been evil; he has brought ruin on his affairs; his dearest friends are in league to injure him. At first this moral perversion extends itself only to a misinterpretation of actual occurrences, which only differs in degree from that which we observe in persons of a morose temper. But, with the advance of the disorder, the mind dwells on its own morbid imaginings, till they come to take the place of actual facts; and in this way *hallucinations* are generated—i. e., creations of the imagination, which are accepted as real occurrences. Now, here there is no primary intellectual perversion; the reasoning powers are not disturbed; the patient can discuss with perfect sanity any question that does not touch his morbid feelings; but the representations shaped by his own mind, under the influence of these feelings, being received as truths to the exclusion of his common-sense, all his actions are based on those erroneous data. This condition is merely an intensification of that just described; and the Physician can no more doubt that it depends upon an unhealthy condition of the bodily frame, than that the delirium of fever and the fantasia of Hashish are dependent upon the presence of a poison in the blood.

The Psychologist who neglects such phenomena as these, merely because the inferences drawn from them by the Physiologist have a dangerous flavor of "materialism," seems to me just as blameworthy as the Physiologist who ignores the facts of consciousness, when they do not happen to fit in with his own conclusions. The true Psychologist is he who lays the foundations of his science broad and deep in

the *whole* constitution of the individual man, and his relations to the World external to him; and aims to build it up with the materials furnished by Experience of every kind, mental and bodily, normal and abnormal; ignoring no fact, however strange, that is attested by valid evidence, and accepting none, however authoritatively sanctioned, that will not stand the test of thorough scrutiny.

It is very easy, and doubtless very pleasant, to dispose of "Cerebration" by a sneer; but those who do so may be fairly called upon in the first place to acquaint themselves with a class of facts which they have never studied; and, when they *have* examined them, may be challenged to give some better and more scientific *rationale* of them than that here offered. I should myself rejoice to welcome *any* new light that metaphysics can throw upon such questions as the following:

1. What other than "Physical Antecedents" excite those states of Consciousness which we call *Sensations*, and the Pleasure and Pain associated with them?

2. Does not all Psychological as well as Physiological probability point to the identity of the Sensorial instrumentality through which we become conscious (1) of a *present* Impression, and (2) of a *remembered* Sensation?

3. If, then, a Visual *perception* be immediately dependent on a Physical change in the Sensorium, excited (through the optic nerve) by a Physical change in the Retina, is it not probable that a Visual *conception* depends on a corresponding Physical change in the Sensorium, called forth (through the "nerves of the internal senses") by a Physical change in the cortical substance of the Cerebrum?

4. As *Sensational* Consciousness can be excited by "Physical Antecedents," why should not *Ideational* and *Emotional?*

5. Is there not Psychological as well as Physiological evidence that the excitement of the Ideational consciousness is the result of a *series* of Physical changes taking place in the Cerebrum, as the action of a Mechanism created by its preformed Habits? In what other way are the facts (admitted by Psychologists of all schools) to be accounted for, which indicate the suggestion of one Idea by another through a chain of Associations, some links of which lie outside the "sphere of consciousness?"

6. Is it conceivable that such an oft-recurring phenomenon as the loss of some branch of acquired Knowledge, after a blow on the head or a fever, is a mere *coincidence?* If not, on what other hypothesis than that of "Physical antecedence" can the blow be the *cause* of this Mental *effect?*

7. Is there not as much evidence that "Physical Antecedents" may produce *Moral* Pleasure and Pain, as that they produce *Sensorial* Pleasure and Pain?

8. If in *any* case we admit Physical antecedence as the Cause (in the ordinary language of Science) of Mental Phenomena, why not in

every case of *automatic* Mental activity?—whether this be left altogether uncontrolled, or be in subjection to the will.

9. When a series of Physical sequences comes to be established by the Habitual action of the Cerebrum in particular modes directed or permitted by the Will, is it not consonant to all Physiological probability that the *tendency* to similar sequences should be hereditarily transmitted, like the tendency to bodily habits?—*Contemporary Review.*

THE LONGEVITY OF TREES.

By ELIAS LEWIS.

IN the vegetable world, limits of growth and life are strangely diversified. Multitudes of forms mature and perish in a few days or hours; while others, whose beginning was in a remote antiquity, have survived the habitual period of their kind, and still enjoy the luxuriance of their prime. Some species of unicellular plants are so minute that millions occur in the bulk of a cubic inch, and a flowering plant is described by Humboldt, which, when fully developed, is not more than three-tenths of an inch in height. On the other hand, we have the great *Sequoia*, whose mass is expressed by hundreds of tons, and specimens of the *Eucalyptus*, growing in the gulches of Australia, surpass in height the dome of St. Peter's.

Some of the Fungi mature between the setting and rising of the sun, while the oak at our door, which awakens the memories of our childhood, has not perceptibly changed in bulk in half a century. Trees grow more slowly as they increase in age. Nevertheless, it is certain that growth continues while they continue to live. The development of foliage implies interstitial activity and organization of new material. In its vital processes there is little expenditure of force or waste of substance. Its functions are essentially constructive, and its growth and age are apparently without limits, excepting such as arise from surrounding conditions. Thus many trees represent centuries, and have a permanence that is astonishing and sublime. Travellers stand awe-struck before the monuments which for forty centuries have kept watch by the Nile, but the oldest of these may not antedate the famous dragon-tree of Teneriffe. It is not surprising that the ancients considered trees "immortal," or, as "old as Time."

But, if the life of the tree is continuous, its leaves—the organs of its growth—have their periods of decay, and are types of mortality. The life of man is likened to the "leaf that perishes." In an animal, the vital processes are carried on by a single set of organs, the impairment of which limits the period of its life. With the tree, decay

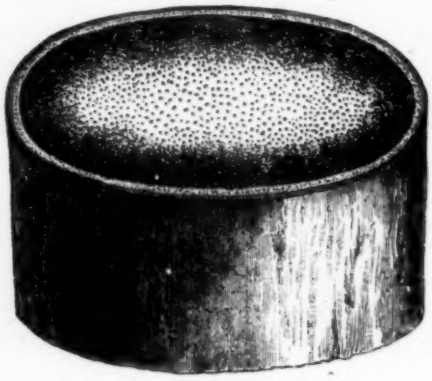
of the organs is followed by constant renovation, and the foliage which covers it the present summer is as new and as young as that which adorned it a hundred or a thousand years ago. Trees which shed their leaves annually, or at longer intervals as do the evergreens,

Fig. 1.

Section of Trunk of Fir-Tree, showing the Annual Rings of Growth.

grow by formation of new wood in layers upon their outer surface, and just beneath the bark. These constitute the class *Exogens*, or outside growers, as shown in Fig. 1. This plate, with others used to illustrate this article, are from Figuier's "Vegetable World," and have been placed at our disposal by the publishers of that interesting work.

Fig. 2.



Section of Palm, without Annual Rings.

A layer represents the growth of a year. Where these are accessible, there is no difficulty in ascertaining the age of a tree, or the rate

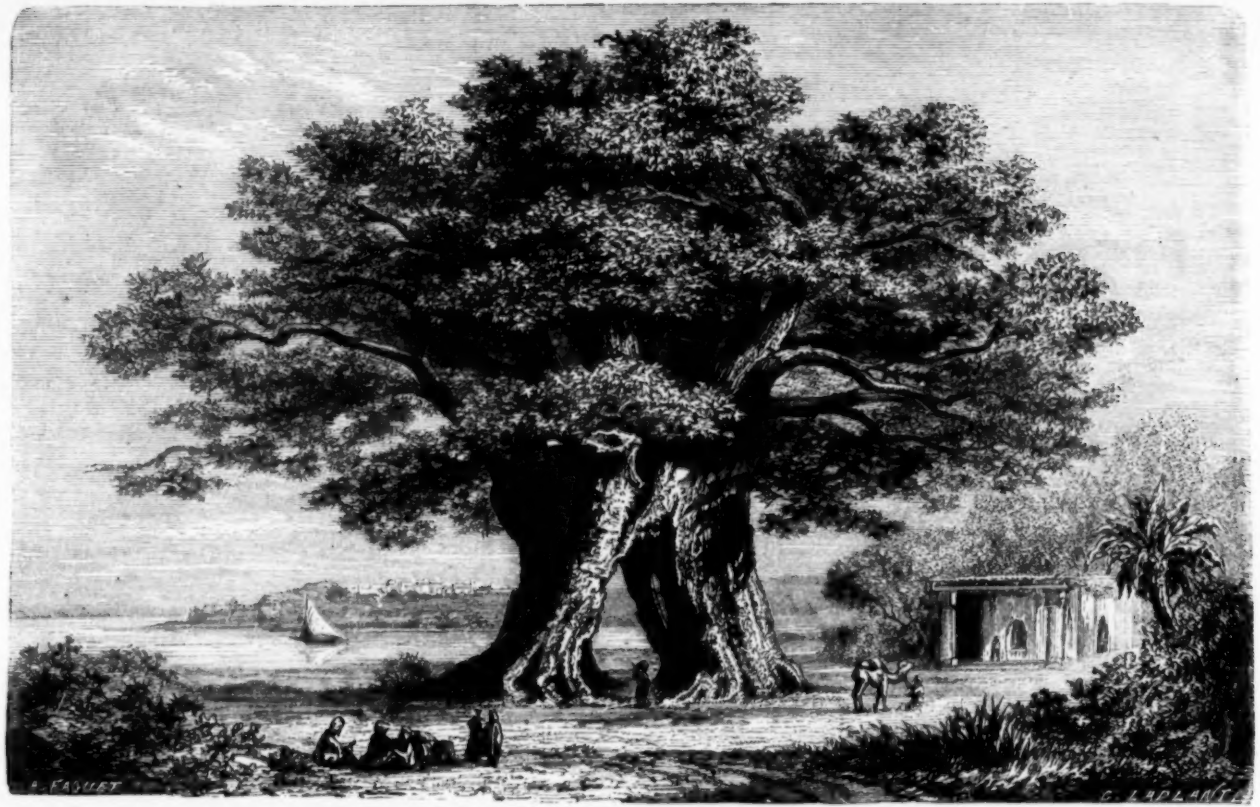
of its growth; and the rate thus ascertained may be applied to other trees of its kind whose diameter is known, although its woody layers be inaccessible. In this way the age of many trees has been estimated. The relation between the age of a tree and its annual rings was first noticed and applied by Montaigne, in 1581.

Fig. 3.

Palm-Trees.

But this method of ascertaining a tree's age does not apply to the class *Endogens*, in which the growth is internal, as shown in Fig. 2.

Fig 4.



Oriental Plane Tree in the Valley of Bujukdere, near Constantinople.

Oriental Plane Tree in the Valley of Bujurdere, near Constantinople.

Fig. 5.

Great Chestnut of Mount Etna.

In these a hard, inflexible shell forms around the inner portions, the tree increases little in diameter, and no woody layers are found. To this class belong the Palms, of which Fig. 3 is an illustration. The age of this class of trees is estimated by comparing specimens with others whose age is known, or from an ascertained rate of growth. The oldest palms may not exceed five centuries, and their average period is probably less than 200 years. The height of the tallest of the species is said to be 192 feet. Trees growing in dense forests are comparatively short-lived, and attain less bulk than those in open places, where side-branches develop in the unobstructed rays of the sun. In similar conditions the age and dimensions attained by trees of each species are tolerably constant. Thus the average period of oaks and pines may be 300 or 400 years; but the exceptions are so numerous and wonderful, that we shall present in this paper a few of the most interesting and best-authenticated instances.

Of the white-pines, once the glory of the New England forests, we are not aware that any have been found more than 430 years old. Nor have we any oaks of extraordinary age. The Charter-oak at Hartford may have been a small tree at the first settlement of New England. The Wadsworth oak, at Geneseo, New York, is said to be five centuries old, and 27 feet in circumference at the base. The massive, slow-growing live-oaks, of Florida, are worthy of notice, on account of the enormous length of their branches. Bartram says: "I have stepped 50 paces in a straight line from the trunk of one of these trees to the extremity of the limbs."

The oaks of Europe are among the grandest of trees. The Cowthorpe oak is 78 feet in circuit at the ground, and is at least 1,800 years old. Another, in Dorsetshire, is of equal age. In Westphalia is a hollow oak, which was used as a place of refuge in the troubled times of mediæval history.

The great oak at Saintes, in Southern France, is 90 feet in girth, and has been ascertained to be 2,000 years old. This monument, still or recently flourishing, commemorates a period which antedates the first campaign of Julius Cæsar!

The oriental plane-tree is noted in Eastern countries for its size and longevity. Fig. 4 represents one near Constantinople, which is 100 feet high, and 150 feet in circuit. It has been suggested that this is really a group of trees originally planted near together for their shade. The figure, however, hardly confirms that opinion, and many trees of this species are mentioned by travellers not greatly inferior to this one in dimensions.

Most of the old plane-trees are hollow, their tops being sustained by wood of recent growth. In this respect an exogenous tree resembles a coral-reef, where the vitality and growth are at the surface only.

Of chestnuts, we have the famous one at Tortworth, in Glou-

Fig. 6.

Cedar of Lebanon.

cestershire, England, which was a large tree in the reign of King Stephen, and is over 1,000 years old. Fig. 5 represents the "Great Chestnut of Mount Etna," consisting, at present, of what appears to be several trees, fragments of the original one. By a writer in the *North American Review*, for July, 1844, these are supposed to be shoots from, rather than portions of, the old tree.

Jean Houel, who examined the trees, says "they are portions of one tree." By removing the soil, the outer rim of the tree has been found, and the circumference ascertained to be 175 feet. Other chestnuts near this are in girth 64, 70, and 72 feet respectively.

The lime or linden, in Europe, is an important tree. Those in the town of Morat are celebrated in the history of Switzerland. One was planted in 1476 to commemorate the defeat of the Burgundians, under Charles the Bold; the other was a noted tree at the time of the battle, and is now near nine centuries old. But, equally famous is the one at Würtemberg, called the "Great Linden," six centuries ago. It is, probably, 1,000 years old, and measures 35½ half feet in girth. Four and a half centuries ago its branches were supported by 67 columns of stone, now increased to 106, many of which are "covered with inscriptions."

The well-known olive-tree is associated with our most cherished recollections. There is an old one near Nice, 24 feet in girth, regarded by the inhabitants with great interest. Those on the Mount of Olives may be contemporary with the Christian era. They are known to have been in existence in 1217, when the Turks captured Jerusalem.

The evergreen cypress, long celebrated for its longevity, is abundant in the burial-grounds of Eastern nations, and, from it dark, dense foliage, forms an impressive feature of Oriental landscapes. In the Palace Gardens of Granada are cypresses said to be 800 years old; and there is one at Somma, in Lombardy, proved by authentic documents "to have been a considerable tree 40 years before the Christian era." Of this family of trees is our well-known white cedar, specimens of which, exhumed from the meadows on the coast of New Jersey, had from 700 to 1,000 rings of wood solid and fragrant as if of recent growth.

The cedars of Lebanon are often referred to in the Sacred Writings. The present trees are, we believe, seven large ones, with many of smaller growth, situated in an elevated valley of the Lebanon Mountains, 6,172 feet above the Mediterranean. The valley is surrounded by peaks of the mountains, which rise 3,000 feet higher, and are covered with snow. Fig. 6 may give some idea of their massive grandeur. De Candolle supposes the oldest are 1,200 years old, but no sections of their wood have been examined to determine their age. The cedar is known to grow slowly, as does the North American or bald cypress, which we will next notice. This tree is common in our

Fig. 7.

Sequoia Gigantea, of California.

Southern States, and its rate of growth has been determined. On the Mexican table-lands its growth and antiquity are immense.

The "Cypress of Montezuma," near the city of Mexico, is 44 feet in girth, and its age is estimated at upward of twenty centuries. In the church-yard of Santa Maria del Tule, in the Mexican State of Oaxaca, is a cypress which "measures 112 feet in circuit, and is without sign of decay." At Palenque are cypresses growing among the ruins of the old city, whose streets they may have shaded in the days of its pride. By the usual methods, the writer in the *North American Review* calculates the age of the cypress at Santa Maria del Tule at 5,124 years, or, if it grew as rapidly during its whole life as similar trees grow when young, it would still be 4,024 years old.

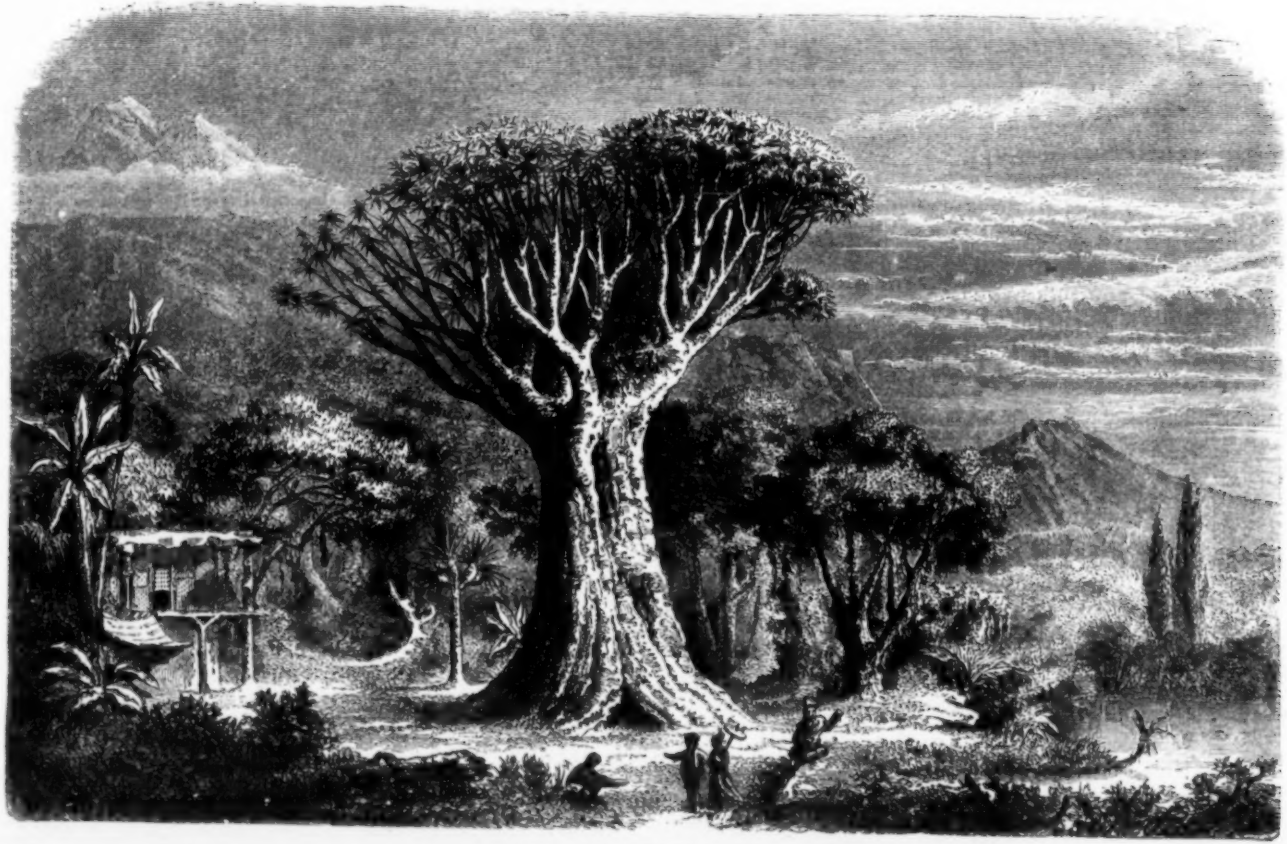
The yew has long been used in Great Britain as an adornment of places of sepulture, and is often referred to in English literature:

> "Beneath these rugged elms, that yew-tree's shade,
> Where heaves the turf in many a mouldering heap."

This tree, of almost imperishable wood, is indigenous to Great Britain. De Candolle ascertained its rate of growth, and concluded that individual specimens are of great antiquity. There is a yew at Ankerwyke House, older than *Magna Charta*. It was an old and celebrated tree when King John met the barons at Runnymede, in 1215, and its age is upward of eleven centuries; but the yews of Fountain's Abbey and the Darley yew are from three to five centuries older than this. In Fortingal Church-yard, Perthshire, is a yew 18 feet in diameter, through decayed portions of which funeral processions pass on their way to the grave. The age of this tree is estimated at 1,800 years. But of greater antiquity is the one described by Evelyn, which stood in Braborne Church-yard, in Kent. It measured 59 feet in girth, and was believed to be 2,500 years old. This tree, which has long disappeared, was probably contemporary with the founding of Rome. The growth and decline of a great empire was spanned by the duration of a single life.

More immense in bulk, but perhaps not older than these living monuments, are the pines of Oregon and the *Sequoias* of California. Mr. Douglas counted 1,100 annual layers in a Lambert pine, and 300 feet is not an unusual height for the Douglas spruce. Hutchings states that a *Sequoia*, which was blown down and measured by him, was 435 feet in length. It was 18 feet in diameter 300 feet from the ground. Scientific observation has connected with these trees an interest equal to that awakened by their size and age. Our most distinguished botanist, Prof. Gray, has shown that the *Sequoias*, now growing on a limited area, had formerly a wide distribution, and are lineal descendants from ancestral types which flourished at least as far back in geologic time as the Cretaceous age. The descent has been with modifications furnishing an important link in the

Fig. 8.



Dragon Tree of Teneriffe

chain of evidence which establishes the derivative origin of specific forms.

Prof. Gray thinks the age of the oldest living *Sequoia* may be about 2,000 years, and remarks: "It is probable that close to the heart of some of the living trees may be found the circle which records the year of our Saviour's nativity." Fig. 7 is a representation of the *Sequoia.*

The sacred banian, before noticed, is familiar to every reader. Its main trunk attains a diameter of from 20 to 30 feet, and its enormous roof of foliage may shelter the inhabitants of a considerable village. The pendent branches are really roots, which, on reaching the ground, penetrate it and form trunks. These correspond with the outer layers of wood in an oak or a pine, and sustain the top, although the original trunks decay and disappear.

The dragon-tree of Orotava, on the island of Teneriffe, is a well-known and historic tree. Our representation of it (Fig. 8) is from a drawing made in 1776. Twice during the present century it has been dismantled by storms. It is but 69 feet high, but is 79 feet in circumference. So slow is its growth that its diameter had scarcely changed in 400 years. Recently it bore flowers and luxuriant foliage, as it may have done before the "isles of the Western Ocean," on one of which it was growing, were a dream in the Grecian mythology.

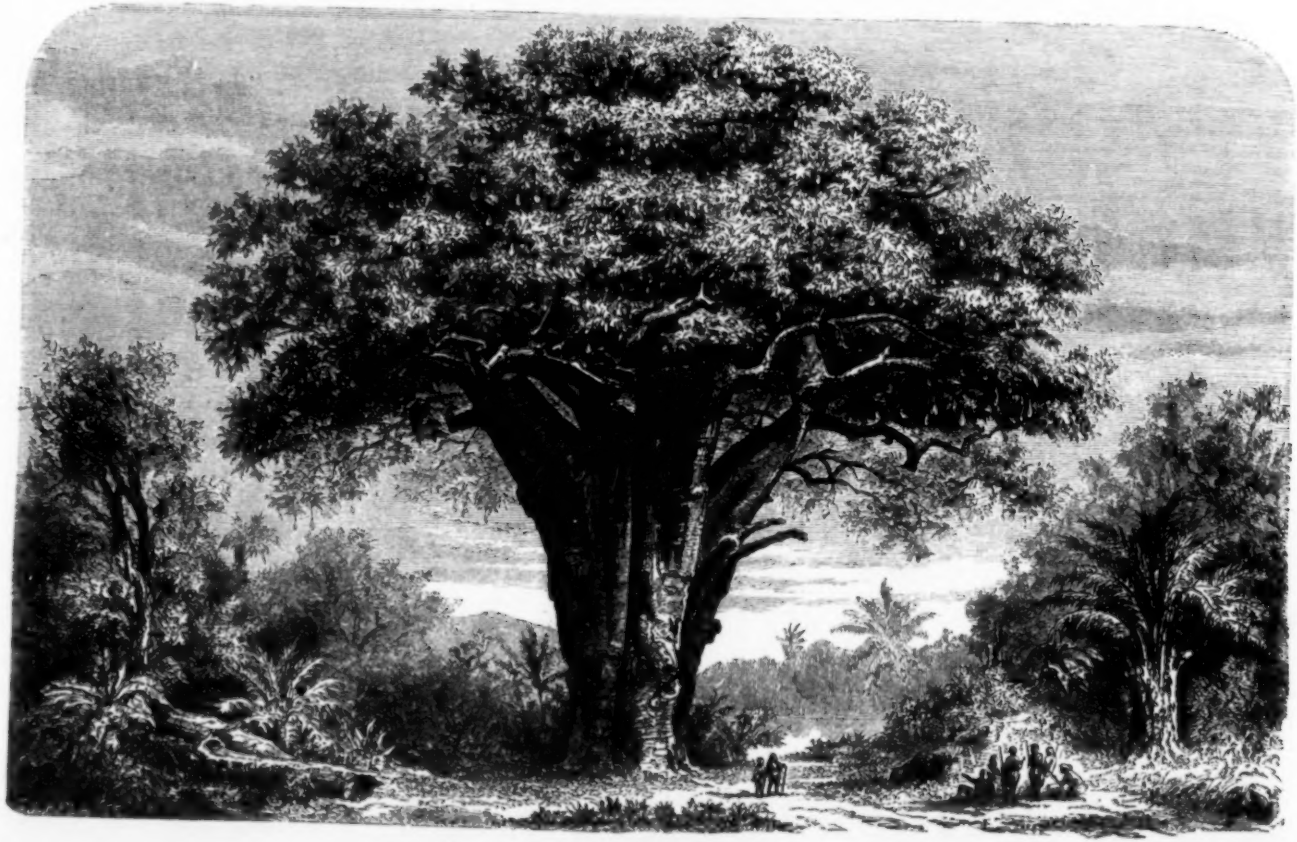
The baobab, or monkey bread-fruit, is the last we can notice of the ancient trees. It was first described by a Venetian traveller in 1454. Fig. 9 is from a photograph of one on the west coast of Africa. These trees are found, however, in nearly all portions of that country south of the Desert, everywhere an imposing feature of the landscape, and objects of regard if not of reverence by the natives. In the rainy season they are in full luxuriance, and are covered with cup-shaped flowers six inches in diameter. The trunks grow from 20 to 60 feet high, but are sometimes 100 feet in circuit at the ground. The baobabs, like most other trees, grow rapidly when young, but slowly when old. Recent estimates attribute to some of the oldest a period of 3,000 years. This is scarcely more than one-half the age assigned to them by early writers.

In 1832 a baobab was transplanted into a garden at Caraccas, which grew as much in 40 years as would have required 100 years by early estimate. An account of this tree is published in *Natur und Leben*, No. 1, 1873.

By the native town of Shupanga, near the Zambesi, in Eastern Africa, is a venerable baobab, beneath which is the grave of Mrs. Livingstone.

Such, briefly, are some of the great living monuments of the vegetable kingdom. In longevity they are in striking contrast with higher types of life. Fixed to a single spot, the tree is what it is because of the forces which act upon it. It is a monument of accumulated and

Fig. 9.



The Baobab, or Monkey Bread-fruit Tree.

concentrated force. Transmuted sunlight is in all its fibres, and who shall estimate the dynamic work which has been expended in its structure?

Dr. Draper observes that "the beat of a pendulum occupies a second of time; divide that period into a million of equal parts, then divide each of these brief periods into a million of other equal parts, a wave of yellow light during one of the last small intervals has vibrated 535 times. Yet that yellow light has been the chief instrument in building the tree." In the delicate texture of its leaves it has overcome molecular force; it has beaten asunder the elements of an invisible gas, and inaugurated a new arrangement of atoms. The old dragon-tree represents forty centuries of this dynamic work—a sublime monument reared without toil by the silent forces of Nature!

In the outer air it has awakened every note of sound, from the softest monotone to the rhythmic roar of the tempest; but in its inner chambers has been a murmur and music of life in the ceaseless movement of fluids and marshalling of atoms, as one by one they take their place in the molecular dance, which eludes the dull sense of hearing, and becomes obvious only in results. The veil which hides these ultimate processes of life has not yet been lifted, and Science pauses in waiting before it, but only waits.

EARLY HINDOO MATHEMATICS.

By Prof. EDWARD S. HOLDEN,
of the National Observatory, Washington.

THERE is a certain fascination in our scanty knowledge of the elder nations of the earth, which is due quite as much to their chronological position as to the intrinsic interest of their doings and sayings; and it owes not a little of its keenness to the very scantiness of that knowledge.

We are continually told that this is a practical century; that we are utilitarians in the strictest sense; that there is no romantic faculty left to us; that we are apt to scorn all knowledge which has not a direct practical bearing on the daily life and interests of us all. How can we believe this when we would so eagerly hear of the autonomy of the Aztecs, and while we care so little for modern Chili, for example?

We can speak with more interest of Karnac than of Bogotá, and a mummy is dearer to us than a Mongolian. We require our thoughts to be suggested sometimes by an age of old and quaint habits, of strange people with stranger gods. In our busy life, it is a relief to turn to the Hindoo, who could spare the time "to sit beneath the tree

and contemplate his own perfections," or to the Egyptian who evolved pyramids, and obelisks, and avenues of sphinxes, out of his infinite leisure.

There are always "the complaining ones," for whom the times are stale, who would lament with Sir Thomas Browne that "mummy is become merchandise, Mizraim cures wounds, and Pharaoh is sold for balsams;" but they forget that the great nineteenth century buys its mummies in order to have a good look at them, and that it studies the Rosetta Stone out of pure interest, and to make no money.

But the real interest of former ages is the study of their manner of thought. We study *what* they thought to determine *how* they thought it. We have an immense and vague curiosity to connect our minds with the minds of long ages ago. Half the fascination of Darwin, Tylor, Lubbock, and Wilson, is from this cause.

It piques us to know that, sixteen hundred years before our era, there was a poet who sang:

> "Like as a plank of drift-wood
> Tossed on the watery main,
> Another plank encounters,
> Meets—touches—parts again;
> So, tossed, and drifting, ever
> On life's unresting sea,
> Men meet, and greet, and sever,
> Parting eternally." [1]

This surely is not the verse of a primitive people; these are not the feeble lispings of the infants of our race; did it not require *time* to accustom the Hindoo mind to similes as complex as these? This verse would not seem childish if Tennyson had written it; it appeals to as deep a consciousness as Coleridge's "Hymn in the Vale of Chamounix," and would even bear comparison with the "Peter Bell" of the great Lake poet.

If this people was so old thirty-four hundred years ago, when was it young? We begin to believe, with Bailly,[2] in the existence of "ce peuple ancien qui nous a tout appris, excepté son nom et son existence."

It may, then, be interesting for us to glance at the state of science among these predecessors of ours. But let us remember that we are applying a severe test, when we compare their progress with the science of to-day. Let us remember that it is only within a hundred years that the return of comets has been predicted; that our knowledge of the constitution of the sun has been gained since 1859; that Newton has been dead only 147 years, and that Lagrange and La-

[1] "Book of Good Councils: written in Sanscrit, B. C. 1600;" translated by Edwin Arnold, M. A., Oxford, 1861.

[2] "This ancient people who have taught us every thing but their own name and their own existence."

place both lived and worked in our own century. When we consider what astronomy would be without these three great men—that is, what it *was* only so few years ago—we are better prepared to appreciate the studies which laid the remote foundations of their triumphs.

It would be impossible, within moderate limits, to determine the value of *Hindoo astronomy*, however interesting the effort might be, since we should enter at once into debateable ground, and come among great authorities in conflict.

Bailly, Delambre, Bentley, Davis, Hunter, Sir William Jones, and others, have various, often contradictory, beliefs to maintain. Some are partisans of the Greek, some of the Arab, others of the Hindoo scientists of long ago. But, fortunately, some of the original manuscript books of the Hindoos have come down to us: among others various complete treatises on mathematics, and these are authentic and of great age. Precisely of how great age it is difficult to ascertain. Bailly, a Hindoo partisan, accepts the largest estimate; Delambre, a detractor of Hindoo science, and an advocate of the Greek, believes the most important of them to have been written about A. D. 1114; while the translator of this manuscript, Colebrooke, a distinguished Sanscrit scholar, places the date of writing in A. D. 1150.

This treatise, the "Lílívatí" of Bháscara Achárya, is supposed to have been a compilation, and there are reasons for believing a portion of it to have been written about A. D. 628. However this may be, it is of the greatest interest, and its date is sufficiently remote to give to Hindoo mathematics a respectable antiquity.

The "Lílívatí," according to Delambre, was written to console the daughter of its author for her ill-success in obtaining a husband, and it speaks well for the Hindoo gentlewoman that such a means could be considered worth the attempting. It was called by her name, and many of the questions are addressed to her, as we shall see.

It opens most auspiciously with an invocation to Ganesa, as follows: "Having bowed to the Deity whose head is like an elephant's; whose feet are adored by gods; who, when called to mind, relieves his votaries from embarrassment, and bestows happiness upon his worshippers; I propound this easy process of computation, delightful by its elegance, perspicuous with words concise, soft, and correct, and pleasing to the learned."

Thus fairly launched, the author gives various tables of Hindoo moneys, weights, etc., and proceeds to business, not without another invocation, however, shorter this time: "Salutation to Ganesa, resplendent as a blue and spotless lotus; and delighting in the tremulous motion of the dark serpent, which is perpetually twining within his throat."

The principles of numeration and addition are then stated concisely, and he affably propounds his first question: "Dear, intelligent Lílívatí, if thou be skilled in addition and subtraction, tell me the sum

of 2, 5, 32, 193, 18, 10, and 100, added together; and the remainder when their sum is subtracted from 10,000."

He then rapidly plunges into multiplication as follows: "Example. Beautiful and dear Lílívatí, whose eyes are like a fawn's! tell me what are the numbers resulting from 135 taken into 12? .... Tell me, auspicious woman, what is the quotient of the product divided by the same multiplier?"

The treatise continues rapidly through the usual rules, but pauses at the reduction of fractions to hold up the avaricious man to scorn: "The quarter of a sixteenth of the fifth of three-quarters of two-thirds of a moiety of a *dramma* was given to a beggar by a person from whom he asked alms; tell me how many cowry-shells the miser gave if thou be conversant in arithmetic with the reduction termed subdivision of fractions."

The "venerable preceptor," as Bháscara calls himself, illustrates what he terms the rule of supposition by the following example: "Out of a swarm of bees, one-fifth part settled on a blossom of *Cadamba;* and one-third on a flower of *Silind'hri;* three times the difference of those numbers flew to the bloom of a *Cutaja.* One bee which remained, hovered and flew about in the air, allured at the same moment by the pleasing fragrance of a jasmin and pandanus. Tell me, charming woman, the number of bees."

This example is sufficiently poetical, but there is given a section on interest, and one on purchase and sale for merchants. It is easily seen that this arithmetic varies but little from that taught in our common schools to-day. The processes are nearly the same, and the advance of the Hindoos in this science is due largely to their admirable system of notation, viz., that called the Arabic, which, however, was undoubtedly derived by the Arabs from Hindoo teachers, as is admitted by the best authorities.

The next section of the book is occupied with a kind of arithmetical geometry, which has for its basis the relation between the squares of the sides of a right-angled triangle. The demonstration of this celebrated theorem is given both geometrically and algebraically by one of the commentators. This algebraic demonstration is so short and so direct that it will be given: If C and D are the greater and less sides of a right-angled triangle, and B the hypothenuse whose greater and less segments are c and d, then—

$$B : C = C : c \quad \text{or} \quad c = \frac{C^2}{B}$$

$$\text{Also,} \qquad B : D = D : d \quad \text{or} \quad d = \frac{D^2}{B}$$

$$\text{Therefore } B = c + d = \frac{C^2}{B} + \frac{D^2}{B} \text{ and } B^2 = C^2 + D^2.$$

It is noteworthy that Wallis, in his "Treatise on Angular Sections,"

(Chapter VI.), gives this demonstration, and supposes it to be given for the first time.

The Hindoos, however, were not skilled in geometry. One of their authors even chides another for attempting to prove geometrically what can be seen by experience. One of the aphorisms of the present treatise is as follows: "That figure, though rectilinear, of which sides are proposed by some presumptuous person, wherein one side equals or exceeds the sum of the other sides, may be known to be no figure;" and the proof of this is thus given, "Let straight rods, of the length of the proposed sides, be placed on the ground, and the incongruity will be apparent."

The geometry of the circle in "Lílívatí" is the best feature of the book on plane figures. The "rule" of the text is that the ratio of the diameter to the circumference is $\frac{3927}{1250}$, or 3.1416 exactly.

This is given in the text without demonstration, but one of the commentators thus establishes it: the side of the inscribed hexagon is first found to be equal to the radius; the side of the dodecagon is derived from this; "from which, in like manner, may be found the side of a polygon with twenty-four sides; and so on, doubling the number of sides in the polygon until the side be near to the arc. The sum of such sides will be the circumference of the circle, nearly." The side of the polygon of three hundred and eighty-four sides is found, and the ratio given above is deduced.

The explanation of the method of finding the area of the circle is somewhat indirect, and is likewise ingenious. The circle is divided into two semicircles by a diameter: if this diameter is 14, the semi-circumference is equal to $21\frac{1179}{1250}$. Suppose a number of radii drawn, and the semi-circumference developed into a right line; each half of the circle will become a saw-shaped figure (Fig. 1); placing these to-

Fig. 1.

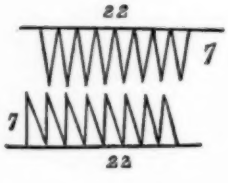
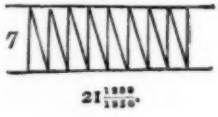


Fig. 2.



gether, we should have a rectangle, Fig. 2, of equal area with the circle. This, of course, leads to the formula, πr^2 *area circle* $= 2\pi r . \frac{r}{2} = \pi . r^2$.

To find the surface of the sphere, and its contents, similar methods are employed.

The following sections are concerned with some practical questions, as the determination of the number of boards which can be cut from a prism of wood, the number of measures of grain in a mound, and formulæ for the length of the shadows of gnomons. Sections on the sub-

jects of permutations follow which are sufficiently obscure, and the treatise concludes with the neat sentiment that "joy and happiness is indeed ever increasing in this world for those who have Lílívatí clasped to their throats. . . ."

Next follows the "Vija-Ganita," a treatise on algebra, of which science the author observes: "Neither is algebra consisting in symbols, nor are the several sorts of it, analysis. Sagacity alone is the chief analysis: for vast is inference."

The methods of Hindoo algebra are rude. Positive quantities have no sign, while negative ones are distinguished by a dot. For the unknown quantities the different *colors* are used, and the initial letters of their names are placed in an equation. Equality must be expressed in words, for the sign was first used by Robert Recorde, who says, "No two things can be more equal than a pair of parallel lines."—(*Hutton.*)

Equations of the first and second degree are treated of, but with obscurity.

It is noteworthy that at least two references are made in this treatise to older authors, which deserve quotation as showing the nature of problems previously proposed.

"Example, by ancient authors. Five doves are to be had for three *drammas;* seven cranes for five; nine geese for seven; and three peacocks for nine: being a hundred of these birds for a hundred *drammas* for the prince's gratification."

"Example by an ancient author. What number multiplied by three and having one added to the product becomes a cube: and the cube root squared and multiplied by three and having one added, becomes a square?"

Enough has been given to show that the Hindoo mind was apt at mathematical logic, and to exhibit the characteristic grace of fancy with which it regarded science.

Arithmetic, when the world was young, was not inconsistent with fancy and with enjoyment. Algebra was regarded with a certain awe. We cannot better illustrate this than by one more quotation from the translation by Colebrooke of the "Vija-Ganita:"

"There is no end of instances, and therefore a few only are exhibited. Since the wide ocean of science is difficultly traversed by men of little understanding, and, on the other hand, the intelligent have no occasion for copious instruction, a particle of tuition conveys science to a comprehensive mind, and, having reached it, expands of its own impulse. . . . The rule-of-three terms constitute arithmetic; and sagacity, algebra."

THE STUDY OF SOCIOLOGY.

By HERBERT SPENCER.

XII.—*The Theological Bias.*

"WHAT a log for hell-fire!" exclaimed a Wahabee, on seeing a corpulent Hindoo. This illustration, startling by its strength of expression, which Mr. Gifford Palgrave gives[1] of the belief possessing these Mohammedan fanatics, prepares us for their general mode of thinking about God and man. Here is a sample of it:

"When 'Abd-el-Lateef, a Wahabee, was preaching one day to the people of Riad, he recounted the tradition according to which Mahomet declared that his followers should divide into seventy-three sects, and that seventy-two were destined to hell-fire, and one only to Paradise. 'And what, O messenger of God, are the signs of that happy sect to which is insured the exclusive possession of Paradise?' Whereto Mahomet had replied, 'It is those who shall be in all conformable to myself and to my companions.' 'And that," added 'Abd-el-Lateef, lowering his voice to the deep tone of conviction, 'that, by the mercy of God, are we, the people of Riad.'"[2]

For present purposes we are not so much concerned to observe the parallelism between this conception and the conceptions that have been, and are, current among sects of Christians, as to observe the effects produced by such conceptions on men's views of those who have alien beliefs, and on the views they are led to form of alien societies. What extreme misinterpretations of social facts result from the theological bias may be seen still better, in a case even more remarkable.

By Turner, by Erskine, and by the members of the United States Exploring Expedition, the characters of the Samoans are, as compared with the characters of the uncivilized generally, very favorably described. Though, in common with savages at large, they are said to be "indolent, covetous, fickle, and deceitful," yet they are also said to be "kind, good-humored, . . . desirous of pleasing, and very hospitable. Both sexes show great regard and love for their children;" and age is much respected. "A man cannot bear to be called stingy or disobliging." The women "are remarkably domestic and virtuous." Infanticide after birth is unknown in Samoa. "The treatment of the sick was . . . invariably humane and all that could be expected." Observe, next, what is said of their cannibal neighbors, the Fijians. They are indifferent to human life; they live in perpetual dread of one another; and, according to Jackson, treachery is considered by them an accomplishment. "Shedding of blood is to him" (the Fijian) "no

[1] "Journey through Central and Eastern Arabia," vol. ii., p. 370.

[2] Ibid., vol. ii., p. 22.

crime, but a glory." They kill the decrepit, maimed, and sick. While, on the one hand, infanticide covers nearer two-thirds than one-half of the births, on the other hand, "one of the first lessons taught the infant is, to strike its mother:" anger and revenge are fostered. Inferiors are killed for neglecting proper salutes; slaves are buried alive with the posts on which a king's house stands; and ten or more men are slaughtered on the decks of a newly-launched canoe, to baptize it with their blood. A chief's wives, courtiers, and aides-de-camp, are strangled at his death—being thereby honored. Cannibalism is so rampant that a chief, praising his deceased son, wound up his eulogy by saying that he would "kill his own wives if they offended him, and eat them afterward." Victims were sometimes roasted alive before being eaten; and Tanoa, one of their chiefs, cut off a cousin's arm, drank the blood, cooked the arm and ate it in presence of the owner, who was then cut to pieces. Their gods, described as having like characters, commit like acts. They eat the souls of those who are devoured by men, having first "roasted" them (the "souls" being simply material duplicates). The Fiji gods "are proud and revengeful, and make war, and kill and eat each other;" and among their names are "the adulterer," "the woman-stealer," "the brain-eater," "the murderer." Such being the account of the Samoans, and such the account of the Fijians, let us ask what the Fijians think of the Samoans. "The Feegeeans looked upon the Samoans with horror, because they had no religion, no belief in any such deities" (as the Feegeean), "nor any of the sanguinary rites which prevailed in other islands"[1]—a fact quite in harmony with that narrated by Jackson, who, having behaved disrespectfully to one of their gods, was angrily called by them "the white infidel."

Any one may read, while running, the lesson conveyed; and, without stopping to consider much, may see its application to the beliefs and sentiments of civilized races. The ferocious Fijian doubtless thinks that, to devour a human victim in the name of one of his cannibal gods, is a meritorious act; while he thinks that his Samoan neighbor, who makes no sacrifices to these cannibal gods, but is just and kind to his fellows, thereby shows that meanness goes along with his shocking irreligion. Construing the facts in this way, the Fijian can form no rational conception of Samoan society. With vices and virtues interchanged in conformity with his creed, the benefits of certain social arrangements, if he thinks about them at all, must seem evils and the evils benefits.

Speaking generally, then, each system of dogmatic theology, with the sentiments that gather round it, becomes an impediment in the way of Social Science. The sympathies drawn out toward one creed and the correlative antipathies aroused by other creeds, distort the interpretations of all the associated facts. On these institutions and

[1] Lubbock's "Prehistoric Times," second edition, p. 442.

their results the eyes are turned with a readiness to observe every thing that is good, and on those with a readiness to observe every thing that is bad. Let us glance at some of the consequent perversions of opinion.

Already we have seen by implication that the theological element of a creed, subordinating the ethical element as it does completely in early stages of civilization and very considerably in later stages, maintains a standard of right and wrong, relatively good perhaps, but perhaps absolutely bad—good, that is, as measured by the requirements of the place and time, bad as measured by the requirements of an ideal society. And, sanctifying, as an associated theology may thus do, false conceptions of right and wrong, it falsifies the measures by which the effects of institutions are to be estimated. Obviously the sociological conclusions must be vitiated if beneficial and detrimental effects are not respectively recognized as such. An illustration enforcing this is worth giving. Here is Mr. Palgrave's account of Wahabee morality, as disclosed in answers to his questions:

"'The first of the great sins is the giving divine honors to a creature.'

"'Of course,' I replied, 'the enormity of such a sin is beyond all doubt. But if this be the first, there must be a second; what is it?'

"'Drinking the shameful,' in English, 'smoking tobacco,' was the unhesitating answer.

"'And murder, and adultery, and false witness?' I suggested.

"'God is merciful and forgiving,' rejoined my friend; 'that is, these are merely little sins.'

"'Hence two sins alone are great, polytheism and smoking,' I continued, though hardly able to keep countenance any longer. And 'Abd-el-Kareem, with the most serious asseveration, replied that such was really the case."[1]

Clearly a creed which makes smoking one of the blackest crimes, and has only mild reprobation for the worst acts committed by man against man, negatives any thing like Social Science. Habits and institutions not being judged by the degrees in which they conduce to social welfare, the ideas of better and worse, as applying to social arrangements, cannot exist; and such notions as progress and retrogression are excluded. But that which holds so conspicuously in this case holds more or less in all cases. At the present time, as in past times, and in our own society as in other societies, public acts are judged by two tests—the test of supposed divine approbation, and the test of conduciveness to human welfare. Though, as civilization advances, there grows up the belief that the second test is equivalent to the first, though, consequently, conduciveness to human welfare comes to be more directly considered, yet the test of supposed divine approbation, as inferred from the particular creed believed, continues to be very generally used. The wrongness of conduct is conceived as con-

[1] "Journey through Central and Eastern Arabia," vol. ii., p. 11.

sisting in the implied disobedience to the supposed commands, and not as consisting in its intrinsic character as causing suffering to others or to self. Inevitably the effect on sociological thinking is, that institutions and actions are judged more by their apparent congruity or incongruity with the established cult than by their tendencies to further or to hinder well-being.

This effect of the theological bias, manifest enough everywhere, has been forced on my attention by one whose mental attitude often supplies me with matter for speculation—an old gentleman who unites the religion of amity and the religion of enmity in startling contrast. On the one hand, getting up early to his devotions, going to church even at great risk to his feeble health, always staying for the sacrament when there is one, he displays what is ordinarily regarded as an exemplary piety. On the other hand, his thoughts ever tend in the direction of warfare: fights on sea and land furnish topics of undying interest to him; he revels in narratives of destruction; his talk is of cannon. To say that he divides his reading between the Bible and Alison, or some kindred book, is an exaggeration; but still it serves to convey an idea of his state of feeling. Now you may hear him waxing wroth over the disestablishment of the Irish Church, which he looks upon as an act of sacrilege; and now, when the conversation turns on works of art, he names, as engravings which above all others he admires, Cœur-de-Lion fighting Saladin, and Wellington at Waterloo. Or, after manifesting some kindly feeling, which, to give him his due, he frequently does, he will shortly pass to some bloody encounter, the narration of which makes his voice tremulous with delight. Marvelling though I did at first over these incongruities of sentiment and belief, the explanation was reached on observing that the subordination-element of his creed was far more dominant in his consciousness than the moral element. Watching the movements of his mind made it clear that, to his imagination, God was symbolized as a kind of transcendently powerful sea-captain, and made it clear that he went to church from a feeling akin to that with which, as a middy, he went to muster. On perceiving that this, which is the sentiment common to all religions, whatever be the name or ascribed nature of the deity worshipped, was supreme in him, it ceased to be inexplicable that the sentiment to which the Christian religion specially appeals should be so readily overridden. It became easier to understand how, when the Hyde-Park riots took place, he could wish that we had Louis Napoleon over here to shoot down the mob, and how he could recall, with more or less of chuckling, the deeds of press-gangs in his early days.

That the theological bias, thus producing conformity to moral principles from motives of obedience only, and not habitually insisting on such principles because of their intrinsic value, obscures sociological truths, will now not be difficult to see. The tendency is to substitute formal recognitions of such principles for real recognitions. So long

as they are not contravened directly enough to suggest disobedience, they may be readily contravened indirectly; for the reason that there has not been cultivated the habit of contemplating consequences as they work out in remote ways. Hence it happens that social arrangements essentially at variance with the ethics of the creed give no offence to those who are profoundly offended by whatever seems at variance with its theology. Maintenance of the dogmas and forms of the religion becomes the primary, all-essential thing; and the secondary thing, often sacrificed, is the securing of those relations among men which the spirit of the religion requires. How conceptions of good and bad in social affairs are thus warped, the pending controversy about the Athanasian creed shows us. Here we have theologians who believe that our national welfare will be endangered, if there is not in all churches an enforced repetition of the dogmas that Father, Son, and Holy Ghost, are each of them Almighty; that yet there are not three Almighties, but one Almighty; that one of the Almighties suffered on the cross and descended into hell to pacify another of them; and that, whoever does not believe this, "without doubt shall perish everlastingly." They say that, if the State makes its priests threaten with eternal torments all who doubt these doctrines, things will go well; but, if those priests, who, in this threat, perceive the devil-worship of the savage usurping the name of Christianity, are allowed to pass it by in silence, woe to the nation! Evidently the theological bias leading to such a conviction entirely excludes Sociology, considered as a science.

Under its special forms, as well as under its general form, the theological bias brings errors into the estimates men make of societies and institutions. Sectarian antipathies, growing out of differences of doctrine, disable the members of each religious community from fairly judging other religious communities. It is always difficult, and often impossible, for the zealot to conceive that his own religious system and his own zeal on its behalf may have but a relative truth and a relative value; or to conceive that there may be relative truths and relative values in alien beliefs and the fanaticisms which maintain them. Though the adherent of each creed has continually thrust on his attention the fact that adherents of other creeds are no less confident than he is—though he can scarcely fail sometimes to reflect that these adherents of other creeds have, in nearly all cases, simply accepted the dogmas current in the places and families they were born in, and that he has done the like—yet the special theological bias which his education and surroundings have given him, makes it almost beyond imagination that these other creeds may, some of them, have justifications as good as, if not better than, his own, and that the rest, along with certain amounts of absolute worth, may have their special fitnesses to the people holding them.

We cannot doubt, for instance, that the feeling with which Mr. Whalley or Mr. Newdegate regards Roman Catholicism must cause extreme reluctance to admit the services which Roman Catholicism rendered to European civilization in the past; and must make almost impossible a patient hearing of any one who thinks that it renders some services now. Whether great benefit did not arise in early times from the tendency toward unification produced within each congeries of small societies by a common creed authoritatively imposed?—whether papal power, supposed to be divinely deputed, and therefore tending to subordinate the political authorities during turbulent feudal ages, did not serve to curb warfare and further civilization?—whether the strong tendency shown by early Christianity to lapse into separate local paganisms, was not beneficially checked by an ecclesiastical system having a single head supposed to be infallible?—whether morals were not improved, manners softened, slavery ameliorated, and the condition of women raised, by the influence of the Church, notwithstanding all its superstitions and bigotries?—are questions to which Dr. Cumming, or other vehement opponent of popery, could not bring a mind open to conviction. Similarly, it is beyond the power of the Roman Catholic to see the meaning of Protestantism, and recognize its value. To the Ultramontane, holding that the temporal welfare no less than the eternal salvation of men depends on submission to the Church, it is incredible that Church-authority has but a transitory value, and that the denials of authority which have come along with accumulation of knowledge and change of sentiment, mark steps from a lower social *régime* to a higher. Naturally, to the sincere Papist, schism is a crime, and books that throw doubt on the established beliefs are accursed. Nor need we wonder when from such a one there comes a saying like that of the Mayor of Bordeaux, so much applauded by the Comte de Chambord, that "the Devil was the first Protestant;" or when, along with this, there goes a vilification of Protestants too repulsive to be repeated. Clearly, with such a theological bias, fostering such ideas respecting Protestant morality, there must be extremely false estimates of Protestant institutions, and of all the institutions going along with them.

In less striking ways, but still in ways sufficiently marked, the special theological bias warps the judgments of Conformists and Nonconformists among ourselves. A fair estimate of the advantages which our State-Church has yielded is not to be expected from the zealous dissenter: he sees only the disadvantages. Whether voluntaryism could have done centuries ago all that it can do now?—whether a State-supported Protestantism was not once the best thing practicable?—are questions which he is unlikely to discuss without prejudice. Contrariwise, the churchman is reluctant to believe that the union of Church and State is beneficial only during a certain phase of progress. He knows that within the Establishment divisions are daily increasing,

while voluntary agency is daily doing a larger share of the work originally undertaken by the State; but he does not join this with the fact that outside the Establishment the power of Dissent is growing: he resists the inference that these changes are parts of a general change by which the political and religious agencies, which have been differentiating from the beginning, are being separated and specialized. He is averse to the conception that just as Protestantism at large was a rebellion against an Ecclesiasticism which dominated over Europe, so Dissent among ourselves is a rebellion against an Ecclesiasticism which dominates over England; and that the two are but successive stages of the same beneficial development. That is to say, his bias prevents him from contemplating the facts in a way favorable to scientific interpretations of them.

Everywhere, indeed, the special theological bias accompanying a special set of doctrines inevitably prejudges many sociological questions. One who holds a creed as absolutely true, and who by implication holds the multitudinous other creeds to be absolutely false in so far as they differ from his own, cannot entertain the supposition that the value of a creed is relative. That a particular religious system is, in a general sense, a natural part of the particular society in which it is found, is an entirely alien conception; and, indeed, a repugnant one. The dogmatic theology which he holds unquestionably true, he thinks good for all places and all times. He does not doubt that, when transplanted to a horde of savages, it will be duly understood by them, duly appreciated by them, and work on them results such as those he experiences from it. Thus prepossessed, he passes over the proofs which recur everywhere, that a people is no more capable of suddenly receiving a higher form of religion than it is capable of suddenly receiving a higher form of government; and that inevitably with such religion, as with such government, there will go on a degradation that presently reduces it to one differing but nominally from that which previously existed. In other words, his special theological bias blinds him to an important class of sociological truths.

The effects of the theological bias need no further elucidation. We will turn our attention to the distortions of judgment caused by the anti-theological bias. Not only the actions of religious dogmas, but also the reactions against them, are disturbing influences we have to beware of. Let us glance first at an instance of that indignation against the established creed, which all display more or less when they emancipate themselves from it.

"A Nepaul king, Rum Bahadur, whose beautiful queen, finding that her lovely face had been disfigured by small-pox, poisoned herself, 'cursed his kingdom, her doctors, and the gods of Nepaul, vowing vengeance on all.' Having ordered the doctors to be flogged, and the right ears and nose of each to be cut off, 'he then wreaked his vengeance on the gods of Nepaul, and, after abusing

them in the most gross way, he accused them of having obtained from him twelve thousand goats, some hundred-weight of sweetmeats, two thousand gallons of milk, etc., under false pretences.' . . . He then ordered all the artillery, varying from three- to twelve-pounders, to be brought in front of the palace. . . . All the guns were then loaded to the muzzle, and down he marched to the headquarters of the Nepaul deities. . . . All the guns were drawn up in front of the several deities, honoring the most sacred with the heaviest metal. When the order to fire was given, many of the chiefs and soldiers ran away panic-stricken, and others hesitated to obey the sacrilegious order; and not until several gunners had been cut down, were the guns opened. Down came the gods and goddesses from their hitherto sacred positions; and, after six hours' heavy cannonading, not a vestige of the deities remained."[1]

This, which is one of the most remarkable pieces of iconoclasm on record, exhibits in an extreme form the reactive antagonism usually accompanying abandonment of an old belief—an antagonism that is high in proportion as the previous submission has been profound. By stabling their horses in cathedrals and treating the sacred places and symbols with intentional insult, the Puritans displayed this feeling in a marked manner; as again did the French revolutionists by pulling down sacristies and altar-tables, tearing mass-books into cartridge-papers, drinking brandy out of chalices, eating mackerel off patenas, making mock ecclesiastical processions, and holding drunken revels in churches. Though in our day the breaking of bonds less rigid, effected by struggles less violent, is followed by a less excessive opposition and hatred, yet habitually the throwing-off of the old form implies a replacing of the previous sympathy by more or less of antipathy: perversion of judgment caused by the antipathy taking the place of that caused by the sympathy. What before was reverenced as wholly true is now scorned as wholly false; and what was regarded as invaluable is now rejected as of no value at all.

In some, this state of sentiment and belief continues. In others, the reaction is in course of time followed by a re-reaction. To carry out the Carlylean figure, the old clothes that had been outgrown and were finally torn off and thrown aside with contempt, come presently to be looked back upon with more calmness and with the recognition that they did good service in their time—nay, perhaps with the doubt whether they were not thrown off too soon. This re-reaction may be feeble or may be strong; but only when it takes place in due amount is there a possibility of balanced judgments either on religious questions or on those questions of Social Science into which the religious element enters.

Here we have to glance at the sociological errors into which the anti-theological bias betrays those in whom it does not become qualified. Thinking only of what is erroneous in the rejected creed, they ignore the truth for which it stands; contemplating only its mischiefs,

[1] "Five Years' Residence in Nepaul," by Captain Thomas Smith, vol. i., p. 168.

they overlook its benefits; and, doing this, they think that nothing but good would result from its general abandonment. Let us observe the tacit assumptions made in drawing this conclusion.

It is assumed, in the first place, that adequate guidance for conduct in life, private and public, could be had; and that a moral code, rationally elaborated by men as they now are, would be duly operative upon them. Neither of these propositions commends itself when we come to examine the evidence. We have but to observe human action as it meets us at every turn, to see that the average intelligence, incapable of guiding conduct even in simple matters, where but a very moderate reach of reason would suffice, must fail in apprehending with due clearness the natural sanctions of ethical principles. The unthinking ineptitude with which even the routine of life is carried on by the mass of men, shows clearly that they have nothing like the insight required for self-guidance in the absence of an authoritative code of conduct. Take a day's experience, and observe the lack of thought indicated from hour to hour.

You rise in the morning, and, while dressing, take up a phial containing a tonic, of which a little has been prescribed for you; but, after the first few drops have been counted, succeeding drops run down the side of the phial—all because the lip is shaped without regard to the requirement. Yet millions of such phials are annually made by glass-makers, and sent out by thousands of druggists: so small being the amount of sense brought to bear on business. Now, turning to the looking-glass, you find that, if not of the best make, it fails to preserve the attitude in which you put it; or, if what is called a "box" looking-glass, you see that the maintenance of its position is insured by an expensive appliance that would have been superfluous had a little reason been used. Were the adjustment such that the centre of gravity of the glass came in the line joining the points of support (which would be quite as easy an adjustment), the glass would remain steady in whatever attitude you gave it. Yet year after year tens of thousands of looking-glasses are made without regard to so simple a need. Presently you go down to breakfast, and, taking some Harvey or other sauce with your fish, find the bottle has a defect like that which you found in the phial: it is sticky from the drops which trickle down, and occasionally stain the table-cloth. Here are other groups of traders, similarly so economical of thought that they do nothing to rectify this obvious inconvenience. Having breakfasted, you take up the paper, and, before sitting down, wish to put some coal on the fire. But the lump you seize with the tongs slips out of them, and, if large, you make several attempts before you succeed in lifting it—all because the ends of the tongs are smooth. Makers and venders of fire-irons go on, generation after generation, without meeting this evil by the simple remedy of giving to these smooth ends some projecting points,

or even roughening them by a few burrs with a chisel. Having at length grasped the lump and put it on the fire, you begin to read; but, before you have got through the first column, you are reminded, by the changes of position which your sensations prompt, that men still fail to make easy-chairs. And yet the guiding principle is simple enough. Just that advantage secured by using a soft seat in place of a hard one—the advantage, namely, of spreading over a larger area the pressure of the weight to be borne, and so making the pressure less intense at any one point—is an advantage to be sought in the *form* of the chair. Ease is to be gained by making the shapes and relative inclinations of seat and back such as will evenly distribute the weight of the trunk and limbs over the widest possible supporting surface, and with the least straining of the parts out of their natural attitudes. And yet only now, after these thousands of years of civilization, are there being reached (and that not rationally but empirically) approximations to the structure required.

Such are the experiences of the first hour; and so they continue all the day through. If you watch and criticise, you may see that the immense majority bring to bear, even on those actions which it is the business of their lives to carry on effectually, an extremely small amount of faculty. Get a workman to do something for you that is more or less new, and not the clearest explanations and sketches will prevent him from blundering; and, to any expression of surprise, he will reply that he was not brought up to it: scarcely ever betraying the slightest shame in confessing that he cannot do a thing he was not taught to do. Similarly throughout the higher grades of activity. Remember how generally improvements in manufactures come from outsiders, and you are at once shown with what mere unintelligent routine manufactures are commonly carried on. Examine into the management of mercantile concerns, and you perceive that those engaged in them mostly do nothing more than move in the ruts that have gradually been made for them by the process of trial and error during a long succession of generations. Indeed, it almost seems as though most men made it their aim to get through life with the least possible expenditure of thought.

How, then, can there be looked for such power of self-guidance as, in the absence of inherited authoritative rules, would require them to understand why, in the nature of things, these modes of action are injurious and those modes beneficial—would require them to pass beyond proximate results, and see clearly the involved remote results as worked out on self, on others, and on society?

The incapacity need not, indeed, be inferred; it may be seen, if we do but take an action concerning which the sanctified code is silent. Listen to a conversation about gambling; and, where reprobation is expressed, note the grounds of the reprobation. That it tends toward the ruin of the gambler; that it risks the welfare of family and friends;

that it alienates from business, and leads into bad company—these, and such as these, are the reasons given for condemning the practice. Rarely is there any recognition of the fundamental reason. Rarely is gambling condemned because it is a kind of action by which pleasure is obtained at the cost of pain to another. The normal obtainment of gratification, or of the money which purchases it, implies, in the first place, that there has been put forth equivalent effort of a kind which, in some way, furthers the general good; and implies, in the second place, that those from whom the money is received, get, directly or indirectly, equivalent satisfactions. But in gambling the opposite happens. Benefit received does not imply effort put forth; and the happiness of the winner involves the misery of the loser. This kind of action is therefore essentially anti-social—sears the sympathies, cultivates a hard egoism, and so produces a general deterioration of character and conduct.

Clearly, then, a visionary hope misleads those who think that in an imagined age of reason, which might forthwith replace an age of beliefs but partly rational, conduct would be correctly guided by a code directly based on considerations of utility. A utilitarian system of ethics cannot at present be correctly thought out even by the select few, and is quite beyond the mental reach of the many. The value of the inherited and theologically-enforced code is that it formulates, with some approach to correctness, the accumulated results of past human experience. It has not arisen rationally but empirically. During all past times mankind have eventually gone right after trying all possible ways of going wrong. The wrong-goings have been habitually checked by disaster, and pain, and death; and the right-goings have been continued because not thus checked. There has been a growth of beliefs corresponding to these good and evil results. Hence the code of conduct, embodying discoveries slowly and almost unconsciously made through a long series of generations, has transcendent authority on its side.

Nor is this all. Were it possible forthwith to replace a traditionally-established and supernaturally-warranted system of rules by a system of rules rationally elaborated, no such rationally-elaborated system of rules would be adequately operative. To think that it would implies the thought that men's beliefs and actions are throughout determined by intellect; whereas they are in much larger degrees determined by feeling.

There is a wide difference between the formal assent men give to a proposition they cannot gainsay, and the efficient belief which produces active conformity to it. Often the most conclusive argument fails to produce a conviction capable of swaying conduct; and often mere assertion, with great emphasis and signs of confidence on the part of the utterer, will produce efficient conviction where there is no

evidence, and even in spite of adverse evidence. Especially is this so among those of little culture. Not only may we see that strength of affirmation and an authoritative manner create faith in them, but we may see that their faith sometimes actually decreases if explanation is given. The natural language of belief in another is that which generates their belief—not the logically-conclusive evidence. The dependencies of this they cannot clearly follow; and, in trying to follow it, they so far lose themselves that premisses and conclusion, not perceived to stand in necessary relation, are rendered less coherent than by putting them in juxtaposition and strengthening their connection by a wave of the emotion which emphatic affirmation raises.

Nay, it is even true that the most cultivated intelligences, capable of criticising evidence and valuing arguments to a nicety, are not thereby made rational to the extent that they are guided by intellect apart from emotion. Continually men of the widest knowledge deliberately do things they know to be injurious; suffer the evils that transgression brings; are deterred a while by the vivid remembrance of them; and, when the remembrance has become faint, transgress again. Often the emotional consciousness overrides the intellectual consciousness absolutely, as hypochondriacal patients show us. A sufferer from depressed spirits may have the testimony of his physicians, verified by numerous past experiences of his own, showing that his gloomy anticipations are illusions caused by his bodily state; and yet the conclusive proofs that they are irrational do not enable him to get rid of them; he continues to feel sure that disasters are coming on him.

All which, and many kindred facts, make it certain that the operativeness of a moral code depends much more upon the emotions called forth by its injunctions than on the consciousness of the utility of obeying such injunctions. The feelings excited during early life toward moral principles, by witnessing the social sanction and the religious sanction they possess, influence conduct far more than the perception that conformity to such principles conduces to welfare. And, in the absence of the feelings which manifestations of these sanctions arouse, the utilitarian belief alone would be inadequate to produce conformity.

It is true that the sentiments in the higher races, and especially in superior members of the higher races, are now in considerable degrees adjusted to these principles; the sympathies that have become organic in the most developed men produce some spontaneous conformity to altruistic precepts. Even to such, however, the social sanction, which is in part derived from the religious sanction, is important as strengthening the influence of such precepts. And, to those endowed with less of moral sentiment, these sanctions are still more important aids to guidance.

Thus the anti-theological bias leads to serious error, both when it ignores the essential share hitherto taken by religious systems in

giving force to certain principles of action, in part absolutely good and in part good relatively to the needs of the time, and again when it prompts the notion that now these principles might be so established on rational bases as to rule men effectually through their enlightened intellects.

These errors, however, which the anti-theological bias produces, are superficial compared with the error that remains. The antagonism to superstitious beliefs habitually leads to entire rejection of them. They are thrown aside with the assumption that, along with so much that is wrong, there is nothing right. Whereas the truth, recognizable only after antagonism has spent itself, is, that the wrong beliefs rejected are superficial, and that a right belief hidden by them remains when they have been rejected. Those who defend, equally with those who assail, religious creeds, suppose that every thing turns on the maintenance of the particular dogmas at issue; whereas the dogmas are but temporary forms of that which is permanent.

The process of Evolution which has progressively modified and advanced men's conceptions of the Universe, will continue to modify and advance them during the future. The ideas of Cause and Origin, which have been gradually changing, will change still further. But no changes in them, even when pushed to the extreme, will expel them from consciousness; and there can, therefore, never be an extinction of the correlative sentiments. No more in this than in other things will Evolution alter its general direction: it will continue along the same lines as hitherto. And, if we wish to see whither it tends, we have but to observe how there has been thus far a decreasing concreteness of the consciousness to which the religious sentiment is related, to infer that hereafter this concreteness will further diminish: leaving behind a substance of consciousness for which there is no adequate form, but which is none the less persistent and powerful.

Without seeming so, the development of religious sentiment has been continuous from the beginning; and its nature when a germ was the same as is its nature when fully developed. The savage first shows it in the feeling excited by some display of power in another exceeding his own power—some skill, some sagacity, in his chief, leading to a result he does not understand—something which has the element of mystery and arouses his wonder. To his unspeculative intellect there is nothing wonderful in the ordinary course of things around. The regular sequences, the constant relations, do not present themselves to him as problems needing interpretation. Only anomalies in that course of causation which he knows most intimately, namely, human will and power, excite his surprise and raise questions. And only when experiences of other classes of phenomena become multiplied enough for generalization, does the occurrence of anomalies among these also, arouse the same idea of mystery and the same sentiment of wonder:

hence one kind of fetichism. Passing over all intermediate stages, the truth to be noted is, that as fast as explanation of the anomalies dissipates the wonder they excited, there grows up a wonder at the uniformities—there arises the question how come they to be uniformities? As fast as Science transfers more and more things from the category of irregularities to the category of regularities, the mystery that once attached to the superstitious explanations of them becomes a mystery that attaches to the scientific explanations of them: there is a merging of many special mysteries in one general mystery. The astronomer, having shown that the motions of the Solar System imply a uniform and invariably-acting force he calls gravitation, finds himself absolutely incapable of conceiving the force. Though he helps himself to think of the Sun's action on the Earth by assuming an intervening medium, and finds he *must* do this if he thinks about it at all; yet the mystery reappears when he asks what is the constitution of this medium. Though compelled to use units of ether as symbols, he sees that they can be but symbols. Similarly with the physicist and the chemist. Though the hypothesis of atoms and molecules enables them to work out multitudinous interpretations that are verified by experiment, yet the ultimate unit of matter admits of no consistent conception. Instead of the particular mysteries presented by those actions of matter they have explained, there rises into prominence the mystery which matter universally presents, and which proves to be absolute. So that, beginning with the germinal idea of mystery which the savage gets from a display of power in another transcending his own, and the germinal sentiment of awe accompanying it, the progress is toward an ultimate recognition of a mystery behind every act and appearance, and a transfer of the awe from something special and occasional to something universal and unceasing.

No one need expect, then, that the religious consciousness will die away, or will change the lines of its evolution. Its specialties of form, once strongly marked and becoming less distinct during past mental progress, will continue to fade; but the substance of the consciousness will persist. That the object-matter can be replaced by another object-matter, as supposed by those who think the "Religion of Humanity" will be the religion of the future, is a belief countenanced neither by induction nor by deduction. However dominant may become the moral sentiment enlisted on behalf of Humanity, it can never exclude the sentiment, alone properly called religious, awakened by that which is behind Humanity and behind all other things. The child, by wrapping its head in the bedclothes, may for a moment get rid of the distinct consciousness of surrounding darkness; but the consciousness, though rendered less vivid, survives, and imagination persists in occupying itself with that which lies beyond perception. No such thing as a "Religion of Humanity" can ever do more than temporarily shut out the thought of a Power of which Humanity is but a small and

fugitive product—which was in course of ever-changing manifestation before Humanity was, and will continue through other manifestations when Humanity has ceased to be.

To recognitions of this order the anti-theological bias is a hindrance. Ignoring the truth for which religions stand, it undervalues religious institutions in the past, thinks they are needless in the present, and expects they will leave no representatives in the future. Hence many errors in sociological reasonings.

To the various other forms of bias, then, against which we must guard in studying the Social Science, has to be added the bias, perhaps as powerful and perverting as any, which religious beliefs and sentiments produce. This, both generally under the form of theological bigotry, and specially under the form of sectarian bigotry, affects the judgments about public affairs; and reactions against it give the judgment an opposite warp.

The theological bias, under its general form, tending to maintain a dominance of the subordination-element of religion over its ethical element—tending, therefore, to measure actions by their formal congruity with a creed rather than by their intrinsic congruity with human welfare—is unfavorable to that estimation of worth in social arrangements which is made by tracing out results. And, while the general theological bias brings into Sociology an element of distortion, by using a kind of measure foreign to the science properly so called, the special theological bias brings in further distortions, arising from the special measures of this kind which it uses. Institutions, old and new, home and foreign, are considered as congruous or incongruous with a particular set of dogmas, and liked or disliked accordingly: the obvious result being that, since the sets of dogmas differ in all times and places, the sociological judgments affected by them must inevitably be wrong in all cases but one, and probably in all cases.

On the other hand, the reactive bias distorts conceptions of sociological phenomena by undervaluing religious systems. It generates an unwillingness to see that a religious system is a normal and essential factor in every evolving society; that the specialties of it have certain fitnesses to the social conditions; and that, while its forms are temporary, its substance is permanent. In so far as the anti-theological bias causes an ignoring of these truths, or an inadequate appreciation of them, it causes misinterpretations.

To maintain the required equilibrium, amid the conflicting sympathies and antipathies which contemplation of religious beliefs inevitably generates, is difficult. In presence of the theological thaw going on so fast on all sides, there is on the part of many a fear, and on the part of some a hope, that nothing will remain. But the hopes and the fears are alike groundless; and must be dissipated before balanced judgments in Social Science can be formed. Like the transformations

that have succeeded one another hitherto, the transformation now in progress is but an advance from a lower form, no longer fit, to a higher and fitter form; and neither will this transformation, nor kindred transformations to come hereafter, destroy that which is transformed any more than past transformations have destroyed it.

VENUS ON THE SUN'S FACE.

By R. A. PROCTOR, B. A.,
AUTHOR OF "OTHER WORLDS THAN OURS," ETC.

EACH evening during the month of April the planet of Love could be seen in the west for a few hours after sunset. She set earlier and earlier each successive night—overtaking the sun, as it were—and toward the end of April she could no longer be detected. On the 5th of May she had overtaken the sun, passing him at a distance of about three times his own breadth above or to the north of his disk. When these lines appear she will be a morning star. This passage by the sun is the last made by Venus (at least when on the hither side of him) before the long-desired and now famous transit of December 9, 1874, when, instead of passing *by* the sun, either above or below his disk, as she usually does, she will pass right across his face.

So much has been said of late respecting this approaching phenomenon, and so much importance is deservedly attached to it, that my readers will probably be interested by a brief and simple account of the matter. In particular, some may desire to know what has been the special aim of the controversy recently and still in progress. Before entering on these matters, I shall make a few remarks on the history of former transits.

The first occasion on which Venus was ever seen on the sun's face was on November 24, 1639 (Old Style), corresponding to December 4th (New Style). It is rather singular that then, somewhat as at present, doubts had arisen, owing to a difference of opinion between an astronomer of established reputation and one less known to the scientific world. The Belgian astronomer Lansberg had stated in his "Tables of the Motion of Venus" that no transit would occur in 1639. Young Horrox, while preparing himself for practical observation, undertook (apparently from sheer love of science) the computation of Venus's motions from the tables of Lansberg. These tables were so highly valued by their author that he had spoken of them as superior to all others—"quantum lenta solent inter viburna cupressi." But Horrox recognized many imperfections in them, and at length, as he says, "broke off the useless computation, resolved for the future with my own eyes to observe the positions of the stars in the heavens; but,

lest so many hours should be entirely thrown away," he made use of his results to predict the positions of the planets. "While thus engaged, I received," he proceeds, "my first intimation of the remarkable conjunction of Venus and the sun; and I regard it as a very fortunate occurrence, insomuch as about the beginning of October it induced me, in expectation of so grand a spectacle, to observe with increased attention." Nevertheless, his heart was wroth within him against Lansberg, insomuch that he could not refrain from the extreme step of "forgiving" him in the following agreeable terms: "I pardon, in the mean time, the miserable arrogance of the Belgian astronomer who has overloaded his useless tables with such unmerited praise, and cease to lament the misapplication of my own time, deeming it a sufficient reward that I was thereby led to consider and foresee the appearance of Venus in the sun. But, on the other hand, may Lansberg forgive me" (this is exquisite) "that I hesitated to trust him in an observation of such importance, and from having been so often deceived by his pretensions to universal accuracy that I disregarded the general reception of his tables. . . . Lest a vain exultation should deceive me," he proceeds, "and to prevent the chance of disappointment, I not only determined diligently to watch the important spectacle myself, but exhorted others whom I knew to be fond of astronomy to follow my example; in order that the testimony of several persons, if it should so happen, might the more effectually promote the attainment of truth, and because by observing in different places our purpose would be less likely to be defeated by the accidental interposition of clouds, or any fortuitous impediment." He was particularly anxious because Jupiter and Mercury seemed by their positions to threaten bad weather. "For," says he, "in such apprehension I coincide with the opinion of the astrologers, because it is confirmed by experience; but in other respects I cannot help despising their puerile vanities." Among the astronomers to whom he wrote was his friend Crabtree.[1]

Horrox calculated that the transit would begin at three o'clock in the afternoon of November 24th; but "being unwilling to depend entirely on his own opinion," he began his watch on Saturday, November 23d. On Sunday morning he resumed it, only interrupting it to go to church—so, at least, I interpret his remark that he "was called away by business of the highest importance, which, for these ornamental pursuits," he "could not with propriety neglect. . . . About fifteen

[1] Both these ardent students of astronomy died young. Horrox (or Horrocks, as his name is now more commonly spelled) was but twenty years old when he calculated the transit, so that his feat may not inaptly be compared to that of Adams in calculating the place of the unknown planet Neptune within a few months of taking his degree. Each instance of an early mastery of difficult problems was fated to meet with neglect; but Horrox died before justice had been done him. Adams was quickly able to prove that his work was sound, notwithstanding the coolness with which it had been received by the Astronomer Royal. Horrocks died in 1641, in his twenty-second year. Crabtree is supposed to have been killed at the battle of Naseby Field.

minutes past three," he proceeds, "when I was again at liberty to continue my labors, the clouds, as if by divine interposition, were entirely dispersed, and I was once more invited to the grateful task of repeating my observations. I then beheld a most agreeable spectacle, the object of my sanguine wishes, a spot of unusual magnitude and of a perfectly circular shape, which had already fully entered upon the sun's disk on the left, so that the edges of the sun and Venus perfectly coincided, forming an angle of contact." I pass over his observations, to quote his account of the feelings with which Crabtree witnessed the spectacle of "Venus on the sun's face." "I had written," he says, "to my most esteemed friend William Crabtree, a person who has few superiors in mathematical learning, inviting him to be present at this Uranian banquet, if the weather permitted; and my letter, which arrived in good time, found him ready to oblige me. . . . But the sky was very unfavorable, being obscured during the greater part of the day with thick clouds; and, as he was unable to obtain a view of the sun, he despaired of making an observation, and resolved to take no further trouble in the matter. But a little before sunset—namely, about thirty-five minutes past three—the sun bursting forth from behind the clouds, he at once began to observe, and was gratified by beholding the pleasing spectacle of Venus upon the sun's disk. Rapt in contemplation, he stood for some time motionless, scarcely trusting his own senses, through excess of joy; for we astronomers have, as it were, a womanish disposition, and are overjoyed with trifles, and such small matters as scarcely make an impression upon others; a susceptibility which those who will may deride with impunity, even in my own presence; and, if it gratify them, I too will join in the merriment. One thing I request: let no severe Cato be seriously offended with our follies; for, to speak poetically, what young man on earth would not, like ourselves, fondly admire Venus in conjunction with the sun, *pulchritudinem divitiis conjunctam?*"

Many years passed before another transit of Venus took place. This was the transit of 1761, and it affords striking evidence of the interest with which, even at this early epoch, astronomers regarded the transits of Venus, that Dr. Halley, the first Astronomer Royal, prepared a dissertation on the subject of the transit of 1761 forty-five years before it took place. Considering all the circumstances, he made a very fair prediction—in fact, the calculated time when Venus was to be at her nearest to the middle of the sun's face was only about half an hour in error, whereas the epochs first announced by our present Astronomer Royal for the entrance and exit of Venus during the transit of 1874 were one hour and three-quarters of an hour, respectively, in error. I do not propose here, however, to touch on any of the mathematical matters dealt with by Halley, and I shall content myself with quoting the remarks which he made on the importance of observing Venus with due care for the sake of determining the sun's distance:

"I could wish," he says (I follow Ferguson's translation), "that many observations of the same phenomenon might be taken by different persons at several places, both that we might arrive at a greater degree of certainty by their agreement, and also lest any single observer should be deprived by the intervention of clouds of a sight which I know not whether any man living in this or the next age will ever see again, and on which depends the certain and adequate solution of a problem the most noble, and at any other time not to be attained to. I recommend it, therefore, again and again to those curious astronomers who (when I am dead) will have an opportunity of observing these things, that they would remember this my admonition, and diligently apply themselves with all their might to the making this observation; and I earnestly wish them all imaginable success; in the first place, that they may not, by the unseasonable obscurity of a cloudy sky, be deprived of this most desirable sight; and then that, having ascertained with more exactness the magnitudes of the planetary orbits, it may redound to their immortal fame and glory."

A few years before the transit of 1761, Delisle, the French astronomer, undertook a careful analysis of all the circumstances of the approaching phenomenon. It had been ascertained that the transit of 1761 was only the first of a pair of transits, the second occurring in 1769; and it was found that the method by which Halley had proposed to utilize the earlier transit would not, on this occasion, be altogether suitable. I shall presently describe the methods respectively suggested, but it is necessary to mention them here, in order that the chronological sequence of the events may be recognized. For many who have heard Delisle's method lately spoken of and insisted upon (as in Parliament by Mr. Goschen) have been led to imagine that it is a recent invention, and, again, that it possesses great advantages over Halley's, whereas it was known and discussed before the transits of 1761 and 1769, and, while very properly adopted for the first transit, was as properly superseded by Halley's in the case of the second.

The transit of 1761 (like that which will occur on December 6, 1882) was partially visible in England. It was observed at Greenwich by the Rev. M. Bliss, Astronomer Royal, and at Savile House, near London, by Mr. Short, "in presence," says the account, "of his Royal Highness the Duke of York, accompanied by their Royal Highnesses Prince William, Prince Henry, and Prince Frederick." A great number of observations[1] were made also in different parts of the world, and a sufficiently satisfactory determination of the sun's distance was deduced therefrom.

It was, however, in 1769, that the real attack was made. It was then that the famous expedition of Captain Cook, in the Endeavor, was made, England being the only country which had a station in the Pacific. The arctic regions were visited also, a station being selected at Wardhus, in North Lapland, where the following notable peculiar-

[1] There were 63 observing-stations in all, thus distributed: 13 in North Europe, 8 in England, 15 in France, 6 in Spain, Portugal, and Italy, 16 in Germany, and 3 in other places.

ity was presented—the beginning of the transit was observed before sunset, and the end after sunrise. There were also stations at Kola, Yakutsk in Siberia, Peking, Manila, Batavia, Hudson's Bay, St. Petersburg, St. Joseph in California, and many other places. In all there were no less than 74 observing-stations, whereof 50 were in Europe.

The reader need hardly be reminded that the determination of the sun's distance which was until lately in use in our text-books of astronomy was based on the observations made during the transit of Venus in 1769. Nevertheless it has been shown that those observations, rightly interpreted, give a determination of the sun's distance according well with those which have been obtained by the best modern methods, whether these have depended on observations of the sun himself, or the moon, or Mars—or, lastly, of the swift flight of light.

EVOLUTION AND MIND.[1]

By C. B. RADCLIFFE, M. D., F. R. C. P.

WITH Mr. Herbert Spencer I have much sympathy, and yet I can not be content to stay at the end at which he arrives and stays. I thoroughly sympathize in his belief that all true philosophical reasoning has its end in unity—that there are abundant proofs of this unity in matter and spirit, in things visible and things invisible—that the truths of science and religion find reconciliation in this unity. I reject, as he does, a purely spiritualistic view of things no less than a purely materialistic view. But I cannot agree with him in believing in indefinite evolution. Nor can I agree with him in believing that life and mind are to be interpreted in terms of matter, motion, and force, even though this interpretation be taken as only symbolizing provisionally arbitrary aspects of an Unknown Reality; and least of all can I agree with him in believing that the principle of unity, underlying matter and spirit alike, is merely an Unknown Cause, the Unknowable, a Power without limits of either time or space, of which the nature ever remains inconceivable. Much, no doubt, is of necessity unknowable, but I would not place the limits of thought where Mr. Spencer would place them. On the contrary, I would hold that there is nothing *unreasonable* in widening these limits so as to bring within them an actual God, even the God of the Scriptures, and that by so doing a much more *reasonable* realization of unity is to be found than that which can be found in an Unknown Reality. I would hold, indeed, that the nature of the Unknowable is to be encroached upon in this way, and to this extent, by the power of the reason, and also that

[1] Part of lecture delivered before the Royal College of Physicians, March, 1873.

there is nothing in the speculations to which I am now referring which can stamp as *unreasonable* that particular view of mind and body which it is the object of this lecture to set forth cursorily.

But what of that view of mind which arises out of the doctrine with which the name of Mr. Darwin is at present especially connected —a name which must always command the highest respect of all *naturalists?* Is not the view arising out of the doctrine of evolution altogether at variance with that which I have been led to take in this lecture? Unquestionably so. It is simply impossible to reconcile the two views; and it is also certain that, if that which arises out of the doctrine of evolution be right, the other must be abandoned. What, then, are the facts upon which this doctrine of evolution is based? This is the question. Are they to be read only in favor of this doctrine, or is there another reading? I venture to think that there is another reading; but how can I make good this statement with the hands of the clock standing where they do! At most I can only throw out a hint or two of what I might say on the subject if I had the time, and this is all I propose to do.

No one can believe more firmly than I do that there is a common plan in all animals and in all parts of animals, as well as in all plants and in all parts of plants, or that there is a common unity for the whole organic world, plant and animal alike. No one can believe more firmly than I do that there are manifestations of mind, not dissimilar in kind to human mind, in the brute creation, and that the law of mind is one and the same everywhere. But it does not follow from this belief in unity that I should believe that one organ should be developed into another organ, or one animal or plant into another animal or plant. The doctrine of unity is quite consistent with a belief that there are certain fixed differences in organs or organisms; it has nothing to do with the doctrine of evolution, except, perhaps, in making its acceptance a little less difficult, for it is a little more easy to suppose that a higher creature may be evolved from a lower if there be the same archetypal unity of plan underlying the two; more than this it cannot do.

I cannot doubt that in the embryonic life of the higher animals there is a process of development at work by which the embryo before arriving at maturity passes through certain stages which seem to shadow forth certain permanent states of being lower down in the scale of life. I cannot doubt that in this case the more perfect is preceded by the more crude, and that there is a process of evolution at work up to a given point. But what follows? Certainly not this—that these resemblances are realities, that the embryo of a higher animal, in developing to maturity, passed through a succession of different animals each one a little more perfect than its predecessors. Certainly not more than this—that the higher animal in the embryonic period of its history, without ever ceasing to be itself, passes through certain

stages of development in which there are certain *likenesses*, never very close, to certain forms of animal life lower down than itself in the scale of being—likenesses which simply bear witness to the unity of plan in all forms of animal life.

I also find it difficult to twist the marvellous improvability of man into an argument for the doctrine of evolution. Who shall say that this improvability is not restricted within certain prescribed limits? As yet man, in his struggle for life, has never turned his opportunities for natural selection so far to account as to make even the slightest advance toward physical improvement. And it is possible that the change for the better which is actually witnessed in man may have to be explained in accordance with the Scriptures rather than in accordance with the doctrine of evolution.

Nor can I rest satisfied with what may be spoken of as the more special evidence in favor of evolution. The pigeon, by developing under cultivation into what may be considered as improved varieties of pigeon, may at first seem to be the subject of evolution; but the changes produced in this way are never more than those minor changes which go to make up the differences called *varieties*, never so great as to constitute another *species* of bird. Moreover, only let the varieties thus produced be let alone for a few generations, and the inevitable result is a return to the original form of the common pigeon, if not to that of the wild, blue rock-pigeon. The history contradicts the notion of evolution rather than confirms it. And so with the dog or any other animal which may be modified as the pigeon is modified; the change produced is never beyond that of mere *variety*, never into that of a new *species;* and let the constraining influences which brought it about come to an end, and, as with the pigeon, it is not long before the original wild form has again cropped out. And what other conclusion can be fairly drawn from the infertility of mules than this—that there is a barrier between different species of animals, even between those which are most closely akin to each other, by which one is prevented from passing into the other. Nay, it is even difficult to find any evidence in favor of evolution in the history of the rudimentary creatures which swarm in dense crowds around the very feet of the scale of being. Here are wonderful changes at work by which, as Dr. Bastian so clearly demonstrates, *bacteria*, the simplest of all living units, may be developed, possibly from inorganic elements, almost at the will of the experimenter, into *monads*, and *amœbæ*, and *paramecia*, or into the lowest forms of *fungus*—into forms of animal life, that is to say, or into forms of vegetable life; but not much is to be built upon this fact in favor of evolution. For what follows? Simply this—that these forms are unstable in the highest degree, and that, instead of passing on into higher forms of being, they presently again break up into their original bacterial units, which units are destined again and again to go through

the same narrow round of combining and separating. The evolution, if evolution it be, is kept within the narrowest limits; the tendency to retrograde is quite as marked as the tendency to go forward; and, as respects evolution, the conclusion to be drawn is even that which has been drawn from the changes witnessed in the pigeon and the dog—this and no other. It may be questioned, also, whether this doctrine of evolution derives as much support as it is supposed to do from the facts belonging to astronomy and geology.

The nebular hypothesis, which may be taken as the real starting-point of the doctrine in question, is certainly very nebulous. The facts upon which it is founded show unity of plan; of that there need be no doubt; but this unity of plan is really a matter quite apart from the nebular hypothesis founded upon it. Besides, where did the heat come from which kept up the nebulous state which preceded the formation of the heavenly bodies of various sorts, and what has become of it since the time of this formation? What real proof is there of the continual cooling which should still be going on according to this view? Like light and gravity, heat may result in the mutual reactions of the heavenly bodies, or be a property of one or other of these bodies; but to conceive of it as independent of these bodies is, to say the least, no easy matter. Indeed, so difficult is it so to conceive of it, that, until the difficulty is overcome, the nebular hypothesis may be set aside as a dream which is as little calculated to give probability to the doctrine of evolution as the evidence which has been already glanced at.

And so likewise with that particular evidence in favor of evolution which the facts of geology are supposed to supply. Endless ages are needed to allow of evolution; and the facts of geology are believed to testify unequivocally to the lapse of these ages. But is it so? If the rock in which the skeleton of a plesiosaurus is embedded had been deposited as slowly as it is supposed to have been deposited, every trace of organization must have decomposed and disappeared long ages before the animal could have been covered up in its bed. For the skeleton to be there at all, indeed, is a plain proof that the rock, at least to the thickness needed for embedding it, must have been deposited before decomposition had time to do its work fully. And so likewise in every other analogous case. Nay, it may even be questioned whether there has been a separate upheaval and sinking to allow of the formation of each coal-seam or limestone-bed, for many of these seams and beds which are parallel may have to be explained as *drifts*, which have to do with *one* cataclysm of upheaval and sinking rather than with *many* such cataclysms, for how could this strict parallelism be preserved if there had been many cataclysms? Moreover, it must not be forgotten that there are not a few fossils out of place in the strata, fossils which ought not to be where they are if living things had made their appearance on the earth in the order required by the doctrine of evolution.

In a word, I fail to find anywhere sufficient reason for believing that man began his history as a marine ascidian, or as a creature still lower down in the scale of being, and that he has worked his way to his present state of civilization by ceaseless strugglings upward—first, in countless forms of brute life, each one succeeding in the series being a little more advanced than that which went before it; and then through an interminable line of savage ancestry, of which the first in the series was only a shade more advanced than the tailless ape of which he was the immediate descendant. And glad I am that it is so; for this idea of imperfect being ever, and almost forever, straining after perfection, and constantly failing in the struggle, produces a feeling approaching to a painful shudder. At any rate, until these and other difficulties are swept away, I find it more easy to accept the doctrine of the creation than to accept the doctrine of evolution, and to believe that each creature was created perfect in itself, and in its relations to all other creatures, and to the universe of which it is a necessary part—so perfect as to deserve to be spoken of at the beginning as "very good"—and that man originally was no brute-descended savage, living in a wilderness, and fighting his way step by step upward to a higher level, but a demi-god, walking and talking in a paradise with the God in whose image he was made, until, for some fault of his own, he was driven out into the wilderness, a slave to body, naked, and all but altogether oblivious of every thing relating to his high original.—*London Lancet.*

IN QUEST OF THE POLE.

FOUR centuries ago the great commercial question of Western Europe related to a new way of getting to the Indies. Columbus struck boldly westward to solve the problem, and, when he encountered land, supposed he had solved it; and named the country India, and the people Indians. But it was at length found that the supposed discovery of Columbus was an illusion, and that a great, new continent barred the way to India. Nothing remained, then, but to go round it if possible, and so navigators struck for a northwest passage. The Cabots traced the American coast from Virginia to Labrador, and attempted to make the passage to India by the north. They failed, and navigators then tried the northeast passage, and, disappointed there, after many years, they turned back again to the alternative route. In May, 1501, Gasper Vasco sailed from Lisbon with two ships to accomplish the northwest passage. These parted company in a storm off the Greenland coast, and Vasco's ship was never heard of again. The next year a brother of Gasper went in

search of him with three ships; the expedition failed, however, and but two ships returned.

In 1576 Martin Frobisher, after begging money of merchants for 15 years to undertake "the only great thing left undone in the world," got off with two small vessels, one of 25 tons and one of 10, and reached Labrador in safety, discovering the strait which is called by his name; but he accomplished nothing more.

In 1585 Captain John Davis started for the northwest with two ships, and got as far as latitude 70°, discovering the strait which bears his name.

In 1607 Henry Hudson was commissioned by certain London merchants to find a route to India across the pole, and, in a little vessel manned by 10 men and one boy, reached the east coast of Greenland, in latitude 70°. He had gone beyond the 80th parallel before his way was blocked by the ice. He made several voyages, the last in 1610 in an ill-provisioned ship and with an unruly crew; but he made his way through the strait and into the bay which bear his name. He was frozen in during the winter; his mutinous crew took control of the ship, and set him adrift in an open boat with his little son and six invalid seamen, and they were never heard of again. After this, expeditions followed rapidly, led by Poole, Button, Bylot, Baffin, Munck, and others. After 1631 little was done in this direction for a century. There was a revival of adventure between 1741 and 1746, but ill-success again discouraged efforts for more than half a century. In 1773 Lord Musgrave attempted to reach the pole, and in 1776 Captain Cook tried to circumnavigate the northern shore of America by way of Behring's Strait.

With the opening of the present century arctic enterprise began to assume a new phase, and was pursued more in the interest of science. If the northwest passage was impossible, it was determined to find out how much was possible in exploring the northern region. To reach the magnetic and geographical poles, and ascertain the conditions of the polar sea and the accompanying phenomena, were now the main objects of adventure. Captain Scoresby, in 1806, reached a point north of Spitzbergen in latitude 81° 30′—510 geographical miles from the pole. He saw an open sea before him, but his vessel was only a whaler, and he was answerable to her owners, so he reluctantly turned back. In 1818 two expeditions sailed—Buchan's and Ross and Parry's. In 1819 Parry set out again, and discovered Prince Regent's Inlet, Barrow Strait, Wellington Channel, Melville Sound, and wintered at Melville Island. Clavering's expedition (1823), Grabb's (1828, Danish), De Blosseville's (1833, French), and Parry's third (1827), were strictly for the purposes of scientific exploration, and not for the discovery of the northwest passage. Sir John Franklin commenced his career as a northern navigator with Captain Buchan, in 1818, as a lieutenant. In 1819, in connection with Dr. Richardson, he set out from Fort

York, Hudson's Bay, on an overland expedition to circumnavigate the northern coast. They were accompanied by Midshipman George Back, afterward Captain Back, a courageous and enterprising explorer. In 1825 Franklin, Richardson, and Back, again set out on an overland expedition for surveying the northern coast. In 1829 Captain John Ross entered Prince Regent's Inlet, and, after surveying the coast of the Boothian Peninsula, he went into winter-quarters. In the spring of 1831 his nephew, James Ross, discovered the north magnetic pole.

In 1837 the coast between Return Reef and Point Barrow was surveyed by Dean and Simpson, in the service of the Hudson's Bay Company. Simpson was the soul of the expedition, and had already made a tramp of over 2,000 miles through the wilderness, and in the depth of winter. Simpson afterward continued the survey, and accomplished a boat-voyage of over 1,600 miles. He died, at the age of thirty-six, by the hand of an Indian assassin.

Sir John Franklin set out on his last voyage in 1845, being then in his sixtieth year, with two ships, the Erebus and the Terror. These vessels were last spoken, July 26th, in the same year, in Baffin's Bay, latitude 77°. In 1848 commenced the *search* for Franklin. The Plover and Hecla took out supplies for him to Behring's Strait. His old companion Richardson went out the same year, as did also Sir James Ross and Captain Bird. In 1850 twelve ships joined in the search, and in 1852 six vessels sailed from England on the same errand. McClure, commanding the Investigator, passed through Behring's Strait in 1850, and safely reached Marcy Bay in 1852, thus discovering the northwest passage. McClintock at length, in the spring of 1859, learned from a party of Esquimaux, on the southwest coast of Boothia-Felix, the mournful story of the fate of Franklin and his men.

Elisha Kent Kane accompanied the first Grinnell expedition (Advance, Lieutenant De Haven) in 1850–'51, and was commander of that vessel in the second Grinnell expedition in 1853. On August 7th he entered Smith's Sound, and, after encountering fearful perils, found a harbor in Rensselaer Bay, latitude 78° 38′. The Advance was fated never to come out of that bay, and had to be abandoned there two years later. April 25, 1854, he set out on a sledge-journey northward, drawn by dogs. May 4th he saw Great Humboldt glacier, and, though scurvy, cold, and dropsy, had wasted his strength, he would still have insisted on advancing, but he now became delirious, and his companions turned their faces shipward. On August 24th, when it was seen that there was no hope of getting the ship free from the ice, Kane called his officers and men together and announced his determination to remain. They were in all 17, and of these nine chose to leave their commander and essay a return home. Kane now adopted the Esquimaux form of house and the Esquimaux diet, as best suited to the climate. He also entered into friendly relations with the natives;

and thus he was enabled to live with comparative comfort in that high latitude. The deserters returned, in great distress, December 12th, the thermometer being then 50° below zero. The entire party abandoned the ship May 20, 1855, and set out on their long journey homeward. They reached New York October 11th.

Dr. Hayes was with Kane in his second voyage, and in 1860 commanded an expedition himself, intending to reach the pole. He took up his winter-quarters at Port Foulke, in Smith's Sound, and penetrated as far north as 82° 45′ on sledges. Dr. Hayes again visited Greenland in the following year, but restricted his labors to the survey of the southern coasts of the peninsula.

The last great polar expedition, which has just closed so eventfully, was in command of Captain Charles Francis Hall, who was born in Cincinnati in 1825. He was apprenticed in early life to a blacksmith, and worked for a time at his trade. He was a man of vigorous and robust development, of courteous and agreeable manners, and, although without a regular scientific education, he had an acute and practical mind. Without having studied the science of navigation, he took to it with enthusiasm, and by tact and experience became a competent commander. In his first voyage (1860) he spent two years and three months in the arctic regions. He went out again in 1864, and stayed five years, and then fully ascertained the time and places where the Franklin company had perished. His last expedition was fitted out by the United States Government, and he sailed from New York June 29, 1871, in the ship Polaris, his object being to find the north-pole. She took supplies from the United States ship Congress at Disco, in Greenland, and in August Captain Hall bade adieu to civilization at Tussisack, and pushed on toward the pole, while for nearly two years nothing was heard from him. A portion of the crew have now returned, from whom we learn that the ship reached latitude 82° 16′, but put back and took up winter-quarters in latitude 81° 38′, and there she was frozen up. On October 10th Captain Hall started on an expedition north, with sledges drawn by Esquimaux dogs, and accompanied by the mate and two Esquimaux. The party was absent two weeks, and returned to the ship on October 24th. Captain Hall was immediately taken sick, and, after fifteen days' illness, he died November 8, 1871. The following year, on August 12th, the Polaris left winter-quarters, got on her beam ends on the 15th of the same month, and was driven south to latitude 77° 35′, when, owing to the heavy pressure of the ice, the vessel was thrown up, and while landing stores broke from her moorings October 15th, with a part of the crew, and drifted away. The party remaining on the ice consisted of 19 persons, five of whom were women and children. They had two boats, and a stock of provisions sufficient for a month, which, by short rations, they determined to make last for five months. One of the boats was used for fuel, and there were no materials for fire. Snow-huts were erected on the ice-

floe, which drifted southward, and was frequently broken up by storms. To add to the horror of their situation, the arctic night set in—the sun disappearing early in December, and not reappearing until the end of January—day being distinguishable from night only by the diurnal streak of light which appeared on the southern horizon. Fortunately the party had rifles and ammunition, and prolonged their lives by killing a few seals, bears, and birds. This life of almost indescribable suffering was continued for over six months, or 197 days. They were at last rescued off Newfoundland by the British steamer Tigress, after having drifted in winter upon the ice a distance of more than 1,500 miles. That the party all survived, and were saved at last in good health, was attributed to the admirable discipline of the company under the intrepid management of Captain Tyson. Of the scientific results of the expedition we as yet know little, but shall perhaps learn more when the Polaris, in charge of Captain Buddington, returns, as she is expected to do this summer.

JOHN STUART MILL.

JOHN STUART MILL, the great English philosopher, is no more. He was born in London, May 20, 1806, and was consequently near sixty-seven years old at the time of his death. His father was James Mill, a man of philosophical intellect and wide attainments, and author of two celebrated works, "The History of British India," and "The Phenomena of the Human Mind." Instead of being sent to school, the son was carefully educated at home under his father's supervision, and in accordance with his ideas. His early education was thoroughly classical, and he was led into the paths of philosophical inquiry in which his father was distinguished. The elder Mill had long been employed in the service of the East India House, and, in 1823, when the son was seventeen years old, his father secured for him a position in the same establishment, which he continued to hold for 35 years. He thus early came in possession of more than a competence, and with abundant leisure to cultivate the rare resources of his mind, and to take his place as a leader of modern thought. While yet a very young man, he contributed various essays of a bold and thoughtful character to the *Edinburgh* and *Westminster Reviews*, and, some years later, he became editor and proprietor of the latter periodical. In 1843, when he was thirty-eight years old, he published the great work which established his world-wide reputation, "The System of Logic;" and, in 1848, appeared his elaborate treatise, "The Principles of Political Economy." In 1851, at the age of forty-five, he married Harriet, daughter of Thomas Hardy, Esq., and widow of John Taylor, a Lon-

don merchant. His wife died at Avignon, in the south of France, in 1858. She was buried there, and her husband raised a monument to her memory, and has since resided there much of his time. He also died at Avignon, and rests in the tomb beside his beloved wife. In 1859 appeared his "Essay on Liberty," and his "Discussions and Dissertations" in 1860. In 1865, when in his sixtieth year, Mr. Mill was elected to Parliament from the district of Westminster, in London, and he was again a candidate, in 1868, in the constituency of Westminster, but was beaten by a rich Tory news-dealer. His work entitled "Considerations on Representative Government" appeared in 1861, and that on "Utilitarianism" in 1863. The work upon which his reputation as a metaphysician will chiefly rest is "The Examination of Sir William Hamilton's Philosophy," published in 1865. In 1869 appeared his little book on the "Subjection of Woman," and his last production, a review of Grote's unfinished "Aristotle," appeared in the *Fortnightly Review* for January of the present year.

In personal appearance Mr. Mill was slight in form, of medium height, somewhat stooping, with a bald head and a conspicuous wen on the left side of the forehead. His small gray eyes were penetrating and restless, and the nose aquiline and prominent. He had thin, compressed lips, with a very decided but agreeable expression of mouth. His face was clean-shaven and bloodless, and he had a perpetual nervous movement—a sort of twitching of the lips and eyes. His manners were unassuming and agreeable, but somewhat diffident and constrained. There was a nervous uncertainty in his movements which at first suggested lameness. He had a thin, weak voice, and spoke at times with a partial stammer. Although no orator, he was a clear, self-possessed, and forcible public speaker, who relied upon argument rather than rhetoric to impress his hearers. In temperament he was far from being the cold, intellectual machine which the readers of his "Logic" might suppose him to be. His nature was sympathetic, and capable of strong attachments, and he could hate his enemies as well as love his friends.

The following sketches and estimates of Mr. Mill's career and character are from the London *Examiner*, which issued a memorial number. Some of the minor contributions have been omitted, and others slightly condensed; but those herewith published form a very valuable summary of Mr. Mill's traits and labors.

HIS EDUCATION AND MARRIAGE.

BY H. R. FOX BOURNE.

James Mill was living in a house at Pentonville when his son was born; and, partly because of the peculiar abilities that the boy displayed from the first, partly because he could not afford to procure for him elsewhere such teaching as he was able himself to give him, he took his education entirely into his own hands. With what

interest—even jealous interest, it would seem—Bentham watched that education, appears from a pleasant little letter addressed to him by the elder Mill in 1812. "I am not going to die," he wrote, "notwithstanding your zeal to come in for a legacy. However, if I were to die any time before this poor boy is a man, one of the things that would pinch me most sorely would be the being obliged to leave his mind unmade to the degree of excellence of which I hope to make it. But another thing is, that the only prospect which would lessen that pain would be the leaving him in your hands. I, therefore, take your offer quite seriously, and stipulate merely that it shall be made as soon as possible, and then we may perhaps leave him a successor worthy of both of us." It was a bold hope, but one destined to be fully realized. At the time of its utterance, the "poor boy" was barely more than six years old. The intellectual powers of which he gave such early proof were carefully, but apparently not excessively, cultivated. Mrs. Grote, in her lately-published "Personal Life of George Grote," has described him as he appeared in 1817, the year in which her husband made the acquaintance of his father: "John Stuart Mill, then a boy of about twelve years old"—he was really only eleven—"was studying, with his father as his sole preceptor, under the paternal roof. Unquestionably forward for his years, and already possessed of a competent knowledge of Greek and Latin, as well as of some subordinate though solid attainments, John was, as a boy, somewhat repressed by the elder Mill, and seldom took any share in the conversation carried on by the society frequenting the house." It is, perhaps, not strange that a boy of eleven, at any rate a boy who was to become so modest a man, should not take much part in general conversation, and Mr. Mill himself never, in referring to his father, led his hearers to suppose that he had, as a child, been in any way unduly repressed by him. The tender affection with which he always cherished his father's memory in no way sanctions the belief that he was at any time subjected to unreasonable discipline. By him his father was only revered as the best and kindest of teachers.

The lad was, in the summer of 1820, sent to France for a year and a half. For several months he lived in Paris, in the house of Jean Baptiste Say, the political economist. The rest of his time was passed in the company of Sir Samuel Bentham, Jeremy Bentham's brother. Early in 1822, before he was eighteen, he returned to London, soon to enter the India Office as a clerk in the department of which his father was chief. In that office he remained for five-and-thirty years, acquitting himself with great ability, and gradually rising to the most responsible position that could be held there by a subordinate.

But, though he was thus early started in life as a city-clerk, his self-training and his education by his father were by no means abandoned. The ancient and modern languages, as well as the various branches of philosophy and philosophical thought in which he was

afterward to attain such eminence, were studied by him in the early mornings, under the guidance of his father, before going down to pass his days in the India Office. During the summer evenings, and on such holidays as he could get, he began those pedestrian exploits for which he afterward became famous, and in which his main pleasure appears to have consisted in collecting plants and flowers in aid of the botanical studies that were his favorite pastime, and something more, all through his life. That he worked early and with wonderful ability in at least one very deep line appears from the fact that, while he was still only a lad, Jeremy Bentham intrusted to him the preparation for the press, and the supplementary annotation, of his "Rationale of Judicial Evidence." That work, for which he was highly commended by its author, published in 1827, contains the first publicly-acknowledged literary work of John Stuart Mill. While he was producing that result of laborious study in a special and intricate subject, his education in all sorts of other ways was continued.

A writer in the *Times* remarks: "He was, by all accounts, an extraordinary child; and it is within our personal knowledge that he was an extraordinary youth when, in 1824, he took the lead at the London Debating Club in one of the most remarkable collections of 'spirits of the age' that ever congregated for intellectual gladiatorship, he being by two or three years the junior of the clique. The rivalry was rather in knowledge and reasoning than in eloquence; mere declamation was discouraged; and subjects of paramount importance were conscientiously thought out."

Having retired from the India House in 1858, Mr. Mill went to spend the winter in Avignon, in the hope of improving the broken health of the wife to whom he was devotedly attached. He had not been married many years, but Mrs. Mill had been his friend since 1835. During more than twenty years he had been aided by her talents and encouraged by her sympathy in all the work he had undertaken, and to her rare merits he afterward paid more than one tribute in terms that have no equal for the intensity of their language and the depth of affection contained in them. Mrs. Mill's weak state of health seems to have hardly repressed her powers of intellect. By her was written the celebrated essay on "The Enfranchisement of Women" contributed to the *Westminster Review*, and afterward reprinted in the "Dissertations and Discussions," with a preface avowing that by her Mr. Mill had been greatly assisted in all that he had written for some time previous. But the assistance was to end now. Mrs. Mill died at Avignon, November 3, 1858, and over her grave was placed one of the most pathetic and eloquent epitaphs that have been ever penned. "Her great and loving heart, her noble soul, her clear, powerful, original, and comprehensive intellect," it was there written, "made her the guide and support, the instructor in wisdom, and the example in goodness, as she was the sole earthly delight, of those who

had the happiness to belong to her. As earnest for all public good as she was generous and devoted to all who surrounded her, her influence has been felt in many of the greatest improvements of the age, and will be in those still to come. Were there even a few hearts and intellects like hers, this earth would already become the hoped-for heaven." Henceforth, during the fourteen years and a half that were to elapse before he should be laid in the same grave, Avignon was the chosen haunt of Mr. Mill.

Passing much of his time in the modest house that he had bought, that he might be within sight of his wife's tomb, Mr. Mill was also frequently in London, whither he came especially to facilitate the new course of philosophical and political writing on which he entered. He found relief also in excursions, one of which was taken nearly every year, in company with his step-daughter, Miss Helen Taylor, into various parts of Europe. Italy, Switzerland, and many other districts were explored, partly on foot with a keen eye both to the natural features of the localities, especially in furtherance of those botanical studies to which Mr. Mill now returned with the ardor of his youth, and also to their social and political institutions.

HIS CAREER IN THE INDIA HOUSE.

BY W. T. THORNTON.

In 1823 the illustrious subject of these brief memoirs, then a lad of seventeen, obtained a clerkship under his father. According to the ordinary course of things in those days, the newly-appointed junior would have had nothing to do, except a little abstracting, indexing, and searching or pretending to search into records; but young Mill was almost immediately set to indite dispatches to the governments of the three Indian Presidencies, on what, in India House phraseology, were distinguished as "political" subjects—subjects, that is, for the most part growing out of the relations of the said governments with "native" states or foreign potentates. This continued to be his business almost to the last. In 1828 he was promoted to be Assistant Examiner, and in 1856 he succeeded to the post of Chief Examiner, after which his duty consisted rather in supervising what his Assistants had written than in writing himself; but, for the three-and-twenty years preceding, he had had immediate charge of the Political Department, and had written almost every "political" dispatch of any importance that conveyed the instructions of the merchant princes of Leadenhall Street to their proconsuls in Asia. Of the quality of these documents it is sufficient to say that they were John Mill's; but, in respect to their quantity, it may be worth mentioning that a descriptive catalogue of them completely fills a small quarto volume of between 300 and 400 pages, in their author's handwriting, which now lies before me; also that the share of the Court of Directors in the correspondence between themselves and the Indian governments used to average annually

about ten huge vellum-bound volumes, foolscap size, and five or six inches thick, and that of these volumes two a year, for more than than twenty years running, were exclusively of Mill's composition; this, too, at times when he was engaged upon such voluntary work in addition as his "Logic" and "Political Economy."

In 1857 broke out the Sepoy war, and in the following year the East India Company was extinguished in all but the name, its governmental functions being transferred to the crown. That most illustrious of corporations died hard, and with what affectionate loyalty Mill struggled to avert its fate is evidenced by the famous petition to Parliament which he drew up for his old masters, and which opens with the following effective antithesis: "Your petitioners, at their own expense, and by the agency of their own civil and military servants, originally acquired for this country its magnificent empire in the East. The foundations of this empire were laid by your petitioners at that time, neither aided nor controlled by Parliament, at the same period at which a succession of administrations under the control of Parliament, were losing by their incapacity and rashness, another great empire on the opposite side of the Atlantic."

I am fortunate enough to be the possessor of the original MS. of this admirable state paper, which I mention, because I once heard its real authorship denied in that quarter of all others in which it might have been supposed to be least likely to be questioned. On one of the last occasions of the gathering together of the proprietors of East India stock, I could scarcely believe my ears, when one of the directors, alluding to the petition, spoke of it as having been written by a certain other official who was sitting by his side, adding after a moment's pause, "with the assistance as he understood, of Mr. Mill," likewise present. As soon as the court broke up, I burst into Mill's room, boiling over with indignation, and exclaiming, "What an infamous shame!" and no doubt adding a good deal more than followed in natural sequence on such an exordium. "What's the matter?" replied Mill, as soon as he could get a word in, "M—— (the director) was quite right. The petition was the joint work of —— and myself." "How can you be so perverse?" I retorted. "You know that I know you wrote every word of it." "No," rejoined Mill, "you are mistaken; one whole line on the second page was put in by ——."

The nearest approach made, throughout our intercourse, to any thing of an unpleasant character, was about the time of his retirement from the India House. Talking over that one day, with two or three of my colleagues, I said it would not do to let Mill go without receiving some permanently visible token of our regard. The motion was no sooner made than it was carried by acclamation. Every member of the Examiner's office—for we jealously insisted on confining the affair to ourselves—came tendering his subscription, scarcely waiting to be asked; in half an hour's time some £50 or £60—I forget the ex-

act sum—was collected, which, in due course, was invested in a superb silver inkstand, designed by our friend Digby Wyatt, and manufactured by Messrs. Elkington. Before it was ready, however, an unexpected trouble arose. In some way or other, Mill had got wind of our proceeding, and, coming to me in consequence, began almost to upbraid me as its originator. I had never before seen him so angry. He hated all such demonstrations, he said, and was quite resolved not to be made the subject of them. He was sure they were never altogether genuine or spontaneous. There were always several persons who took part in them, merely because they did not like to refuse, and in short, whatever we might do, he would have none of it. In vain I represented how eagerly everybody, without exception, had come forward; that we had now gone too far to recede; that if he would not take the inkstand, we should be utterly at a loss what to do with it, and that I myself should be in a specially embarrassing position. Mill was not to be moved. This was a question of principle, and on principle he could not give way. There was nothing left, therefore, but resort to a species of force. I arranged with Messrs. Elkington that our little testimonial should be taken down to Mr. Mill's house at Blackheath, by one of their men, who, after leaving it with the servant, should hurry away without waiting for an answer. This plan succeeded, but I have always suspected, though she never told me so, that its success was mainly due to Miss Helen Taylor's good offices. But for her, the inkstand would almost certainly have been returned, instead of being promoted, as it eventually was, to a place of honor in her own and her father's drawing-room.

HIS MORAL CHARACTER.

BY HERBERT SPENCER.

To dilate upon Mr. Mill's achievements, and to insist upon the wideness of his influence over the thought of his time, and consequently over the actions of his time, seem to me scarcely needful. The facts are sufficiently obvious; and are recognized by all who know any thing about the progress of opinion during the last half-century. My own estimate of him, intellectually considered, has been emphatically, though briefly, given on an occasion of controversy between us, by expressing my regret at "having to contend against the doctrine of one whose agreement I should value more than that of any other thinker."

While, however, it is almost superfluous to assert of him that intellectual height so generally admitted, there is more occasion for drawing attention to a moral elevation that is less recognized, partly because his activities in many directions afforded no occasion for exhibiting it, and partly because some of its most remarkable manifestations in conduct are known only to those whose personal relations with him have called them forth. I feel especially prompted to say something

on this point, because, where better things might have been expected, there has been, not only a grudging recognition of intellectual rank, but a marked blindness to those fine traits of character which, in the valuation of men, must go for more than superiority of intelligence.

It might, indeed, have been supposed that even those who never enjoyed the pleasure of personal acquaintance with Mr. Mill, would have been impressed with the nobility of his nature as indicated in his opinions and deeds. How entirely his public career has been determined by a pure and strong sympathy for his fellow-men—how entirely this sympathy has subordinated all desires for personal advantage—how little even the fear of being injured in reputation or position has deterred him from taking the course which he thought equitable or generous—ought to be manifest to every antagonist, however bitter. A generosity that might almost be called romantic was obviously the feeling prompting sundry of those courses of action which have been commented upon as errors. And nothing like a true conception of him can be formed unless, along with dissent from them, there goes recognition of the fact that they resulted from the eagerness of a noble nature, impatient to rectify injustice, and to further human welfare.

It may, therefore, perhaps, be that my own perception of this pervading warmth of feeling has been sharpened by seeing it exemplified, not in the form of expressed opinions only, but in the form of private actions. For Mr. Mill was not one of those who, to sympathy with their fellow-men in the abstract, join indifference to them in the concrete. There came from him generous acts that corresponded with his generous sentiments. I say this not from second-hand knowledge, but having in mind a remarkable example known only to myself and a few friends. I have hesitated whether to give this example; seeing that it has personal implications. But it affords so clear an insight into Mr. Mill's character, and shows so much more vividly than any description could do how fine were the motives swaying his conduct, that I think the occasion justifies disclosure of it.

Some seven years ago, after bearing as long as was possible the continued losses entailed on me by the publication of the "System of Philosophy," I notified to the subscribers that I should be obliged to cease at the close of the volume then in progress. Shortly after the issue of this announcement, I received from Mr. Mill a letter, in which, after expressions of regret, and after naming a plan which he wished to prosecute for reimbursing me, he went on to say: "In the next place . . . . what I propose is, that you should write the next of your treatises, and that I should guarantee the publisher against loss, i. e., should engage, after such length of time as may be agreed on, to make good any deficiency that may occur, not exceeding a given sum, that sum being such as the publisher may think sufficient to secure him." Now, though these arrangements were of kinds that I could not bring myself to yield to, they none the less profoundly impressed me with

Mr. Mill's nobility of feeling, and his anxiety to further what he regarded as a beneficial end. Such proposals would have been remarkable even had there been entire agreement of opinion. But they were the more remarkable as being made by him under the consciousness that there existed between us certain fundamental differences, openly avowed. I had, both directly and by implication, combated that form of the experiential theory of human knowledge which characterizes Mr. Mill's philosophy; in upholding Realism, I had opposed, in decided ways, those metaphysical systems to which his own Idealism was closely allied; and we had long carried on a controversy respecting the test of truth, in which I had similarly attacked Mr. Mill's positions in an outspoken manner. That under such circumstances he should have volunteered his aid, and urged it upon me, as he did, on the ground that it would not imply any personal obligation, proved in him a very exceptional generosity.

Quite recently I have seen afresh illustrated this fine trait—this ability to bear with unruffled temper and without any diminution of kindly feeling the publicly-expressed antagonism of a friend. The last evening I spent at his house was in the company of another invited guest, who, originally agreeing with him entirely on certain disputed questions, had some fortnight previously displayed his change of view—nay, had publicly criticised some of Mr. Mill's positions in a very undisguised manner. Evidently, along with his own unswerving allegiance to truth, there was in Mr. Mill an unusual power of appreciating in others a like conscientiousness; and so of suppressing any feeling of irritation produced by difference—suppressing it not in appearance only, but in reality; and that, too, under the most trying circumstances.

I should say, indeed, that Mr. Mill's general characteristic, emotionally considered, was an unusual predominance of the higher sentiments—a predominance which tended, perhaps, both in theory and practice, to subordinate the lower nature unduly. That rapid advance of age which has been conspicuous for some years past, and which doubtless prepared the way for his somewhat premature death, may, I think, be regarded as the outcome of a theory of life which made learning and working the occupations too exclusively considered. But, when we ask to what ends he acted out this theory, and in so doing too little regarded his bodily welfare, we see that even here the excess, if such we call it, was a noble one. Extreme desire to further human welfare was that to which he sacrificed himself.

HIS BOTANICAL STUDIES.

BY HENRY TRIMEN.

If we would have a just idea of any man's character, we should view it from as many points and under as many aspects as we can. The side-lights thrown by the lesser occupations of a life are often

very strong, and bring out its less obvious parts into startling prominence. Much especially is to be learned of character by taking into consideration the employment of times of leisure or relaxation, the occupation of such hours being due almost solely to the natural bent of the individual, without the interfering action of necessity or expediency. Most men, perhaps especially eminent men, have a "hobby," some absorbing object, the pursuit of which forms the most natural avocation of their mind, and to which they turn with the certainty of at least satisfaction, if not of exquisite pleasure. The man who follows any branch of natural science in this way is almost always especially happy in its prosecution, and his mental powers are refreshed and invigorated for the more serious and engrossing, if less congenial, occupation of his life. Mr. Mill's hobby was practical field botany; surely in all ways one very well suited to him.

Of the tens of thousands who are acquainted with the philosophical writings of Mr. Mill, there are probably few beyond the circle of his personal friends who are aware that he was also an author in a modest way on botanical subjects, and a keen searcher after wild plants. His short communications on botany were chiefly, if not entirely, published in a monthly magazine called the *Phytologist*, edited from its commencement in 1841 by the late George Luxford till his death in 1854, and afterward conducted by Mr. A. Irvine, of Chelsea, an intimate friend of Mr. Mill's, till its discontinuance in 1863. In the early numbers of this periodical especially will be found frequent notes and short papers on the facts of plant-distribution brought to light by Mr. Mill during his botanical rambles. His excursions were chiefly in the county of Surrey, and especially in the neighborhood of Guildford and the beautiful vale of the Sittingbourne, where he had the satisfaction of being the first to notice several plants of interest, as *Polygonum dumetorum*, *Isatis tinctoria*, and *Impatiens fulva*, an American species of balsam, affording a very remarkable example of complete naturalization in the Wey and other streams connected with the lower course of the Thames. Mr. Mill says he first observed this interloper in 1822, at Albury, a date which probably marks about the commencement of his botanical investigations, if not that of the first notice of the plant in this country. Mr. Mill's copious MS. lists of observations in Surrey were subsequently forwarded to the late Mr. Salmon of Godalming, and have been since published with the large collection of facts made by that botanist in the "Flora of Surrey," printed under the auspices of the Holmesdale (Reigate) Natural History Club. Mr. Mill also contributed to the same scientific magazine some short notes on Hampshire botany, and is believed to have helped in the compilation of Mr. G. G. Mill's "Catalogue of the Plants of Great Marlow, Bucks."

During his frequent and latterly prolonged residence at Avignon, Mr. Mill, carrying on his botanical observations, had become very well

acquainted with the vegetation of the district, and, at the time of his death, had collected a mass of notes and observations on the subject. It is believed to have been his intention to have printed these as the foundation of a flora of Avignon.

In the slight contributions to the literature of botany made by Mr. Mill, there is nothing which gives any inkling of the great intellectual powers of their writer. Though always clear and accurate, they are merely such notes as any working botanical collector is able to supply in abundance. Mainly content with the pursuit as an out-door occupation, with such an amount of home-work as was necessary to determine the names and affinities of the species, Mr. Mill never penetrated deeply into the philosophy of botany, so as to take rank among those who have, like Herbert Spencer, advanced that science by original work either of experience or generalization, or have entered into the battle-field where the great biological questions of the day are being fought over. The writer of this notice well remembers meeting, a few years since, the (at that time) parliamentary logician, with his trousers turned up out of the mud, and armed with the tin insignia of his craft, busily occupied in the search after a marsh-loving rarity in a typical spongy wood on the clay to the north of London.

But, however followed, the investigation of Nature cannot fail to influence the mind in the direction of a more just appreciation of the necessity of system in arrangement, and of the principles which must regulate all attempts to express notions of system in a classification. Traces of this are not difficult to find in Mr. Mill's writings. It may be safely stated that the chapters on classification in the "Logic" would not have taken the form they have had not the writer been a naturalist as well as a logician. The views expressed so clearly in these chapters are chiefly founded on the actual needs experienced by the systematic botanist, and the argument is largely sustained by references to botanical systems and arrangements. Most botanists agree with Mr. Mill in his objections to Dr. Whewell's views of a natural classification by resemblance to "types" instead of in accordance with well-selected characters; and, indeed, the whole of these chapters are well deserving the careful study of naturalists, notwithstanding that the wonderfully rapid progress in recent years of new ideas, lying at the very root of all the natural sciences, may be thought by some to give the whole argument, in spite of its logical excellence, a somewhat antiquated flavor.

HIS PLACE AS A CRITIC.

BY W. MINTO.

It was in his earlier life, when his enthusiasm for knowledge was fresh, and his active mind, "all as hungry as the sea," was reaching out eagerly and strenuously to all sorts of food for thought, literary, philosophical, and political, that Mr. Mill set himself, among other

things, to study and theorize upon poetry and the arts generally. He could hardly have failed to know the most recent efflorescence of English poetry, living as he did in circles where the varied merits of the new poets were largely and keenly discussed. He had lived also for some time in France, and was widely read in French poetry. He had never passed through the ordinary course of Greek and Latin at school and college, but he had been taught by his father to read these languages, and had been accustomed from the first to regard their literature as literature, and to read their poetry as poetry. These were probably the main elements of his knowledge of poetry. But it was not his way to dream or otherwise luxuriate over his favorite poets for pure enjoyment. Mr. Mill was not a cultivator of art for art's sake. His was too fervid and militant a soul to lose itself in serene love and culture of the calmly beautiful. He read poetry for the most part with earnest, critical eye, striving to account for it, to connect it with the tendencies of the age; or he read to find sympathy with his own aspirations after heroic energy. He read De Vigny and other French poets of his generation with an eye to their relations to the convulsed and struggling state of France, and because they were compelled by their surroundings to take life *au sérieux*, and to pursue with all the resources of their art something different from beauty in the abstract. Luxurious passive enjoyment or torpid half-enjoyment must have been a comparatively rare condition of his finely-strung, excitable, and fervid system. I believe that his moral earnestness was too imperious to permit much of this. He was capable, indeed, of the most passionate admiration of beauty, but even that feeling seems to have been interpenetrated by a certain militant apostolic fervor; his love was as the love of a religious soldier for a patron saint, who extends her aid and countenance to him in his wars. I do not mean to say that his mind was in a perpetual glow; I mean only that this surrender to his impassioned transports was more characteristic of the man than serene openness to influx of enjoyment. His "Thoughts on Poetry and its Varieties," while clear and strenuous as most of his thoughts were, are neither scientifically precise, nor do they contain any notable new idea not previously expressed by Coleridge—except, perhaps, the idea that emotions are the main links of association in the poetic mind; still, his working out of the definition of poetry, his distinction between novels and poems, and between poetry and eloquence, is interesting as throwing light upon his own poetic susceptibilities. He holds that poetry is the "delineation of the deeper and more secret workings of human emotion." It is curious to find one, who is sometimes assailed as the advocate of a grovelling philosophy, complaining that the chivalrous spirit has almost disappeared from books of education, that the youth of both sexes of the educated classes are growing up unromantic. "Catechisms," he says, "will be found a poor substitute for the old romances, whether of chivalry or faëry, which, if they did not give a

true picture of actual life, did not give a false one, since they did not profess to give any, but (what was much better) filled the youthful imagination with pictures of heroic men, and of what are at least as much wanted—heroic women."

If it is asked why Mr. Mill, with all his width of knowledge and sympathy, has achieved so little of a reputation as a miscellaneous writer, part of the reason no doubt is, that he sternly repressed his desultory tendencies and devoted his powers to special branches of knowledge, attaining in them a distinction that obscured his other writings. Another reason is, that, although his style is extremely clear, he was for popular purposes dangerously familiar with terms belonging more or less to the schools. He employed these in literary generalizations, without remembering that they were not equally familiar to his readers; and thus general readers, like Tom Moore, or the author of the recent notice in the *Times*, who read more for amusement than instruction, were disposed to consider Mr. Mill's style "vastly unreadable."

HIS WORK IN PHILOSOPHY.

BY J. H. LEVY.

To a savage contemplating a railway-train in motion, the engine would present itself as the master of the situation—the determining cause of the motion and direction of the train. It visibly takes the lead, it looks big and important, and it makes a great noise. Even people a long way up in the scale of civilization are in the habit of taking these attributes, perhaps not as the essential ones of leadership, but at all events as those by which a leader may be recognized. Still, that blustering machine, which puffs and snorts, and drags a vast multitude in its wake, is moving along a track determined by a man hidden away from the public gaze. A line of rail lies separated from an adjacent one, the pointsman moves a handle, and the foaming giant, that would, it may be, have sped on to his destruction and that of the passive crew who follow in his rear, is shunted to another line, running in a different direction and to a more desirable goal.

The great intellectual pointsman of our age—the man who has done more than any other of this generation to give direction to the thought of his contemporaries—has passed away, and we are left to measure the loss to humanity by the result of his labors. Mr. Mill's achievements in both branches of philosophy are such as to give him the foremost place in either. Whether we regard him as an expounder of the philosophy of mind, or the philosophy of society, he is *facile princeps*. Still it is his work in mental science which will, in our opinion, be in future looked upon as his great contribution to the progress of thought. His work on political economy not only put into thorough repair the structure raised by Adam Smith, Malthus, and Ricardo, but raised it at least one story higher. His inestimable "System

of Logic" was a revolution. It hardly needs, of course, to be said that he owed much to his predecessors; that he borrowed from Whewell much of his classification, from Brown the chief lines of his theory of causation, from Sir John Herschel the main principles of the inductive methods. Those who think this a disparagement of his work must have very little conception of the mass of original thought that still remains to Mr. Mill's credit, the great critical power that could gather valuable truths from so many discordant sources, and the wonderful synthetic ability required to weld these and his own contributions into one organic whole.

When Mr. Mill commenced his labors, the only logic recognized was the syllogistic. Reasoning consisted solely, according to the then dominant school, in deducing from general propositions other propositions less general. It was even asserted confidently that nothing more was to be expected—that an inductive logic was impossible. This conception of logical science necessitated some general propositions to start with; and these general propositions being *ex hypothesi* incapable of being proved from other propositions, it followed that, if they were known to us at all, they must be original data of consciousness. Here was a perfect paradise of question-begging. The ultimate major premiss in every argument being assumed, it could, of course, be fashioned according to the particular conclusion it was called in to prove. Thus an "artificial ignorance," as Locke calls it, was produced, which had the effect of sanctifying prejudice by recognizing so-called necessities of thought as the only bases of reasoning. It is true that outside of the logic of the schools great advances had been made in the rules of scientific investigation; but these rules were not only imperfect in themselves, but their connection with the law of causation was but imperfectly realized, and their true relation to syllogism hardly dreamed of.

Mr. Mill altered all this. He demonstrated that the general type of reasoning is neither from generals to particulars, nor from particulars to generals, but from particulars to particulars. "If from our experience of John, Thomas, etc., who once were living but are now dead, we are entitled to conclude that all human beings are mortal, we might surely, without any logical inconsequence, have concluded at once, from those instances, that the Duke of Wellington is mortal. The mortality of John, Thomas, and others is, after all, the whole evidence we have for the mortality of the Duke of Wellington. Not one iota is added to the proof by interpolating a general proposition." We not only may, according to Mr. Mill, reason from some particular instances to others, but we frequently do so. As, however, the instances which are sufficient to prove one fresh instance must be sufficient to prove a general proposition, it is most convenient to at once infer that general proposition which then becomes a formula according to which (but not from which) any number of particular inferences may be

made. The work of deduction is the interpretation of these formulæ, and therefore, strictly speaking, is not inferential at all. The real inference was accomplished when the universal proposition was arrived at.

It will easily be seen that this explanation of the deductive process completely turns the tables on the transcendental school. All reasoning is shown to be at bottom inductive. Inductions and their interpretation make up the whole of logic, and to induction accordingly Mr. Mill devoted his chief attention. For the first time induction was treated as the *opus magnum* of logic, and the fundamental principles of science traced to their inductive origin. It was this, taken with his theory of syllogism, which worked the great change. Both his "System of Logic," and his "Examination of Sir William Hamilton's Philosophy," are for the most part devoted to fortifying this position, and demolishing beliefs inconsistent with it. As a systematic psychologist Mr. Mill has not done so much as either Prof. Bain or Mr. Herbert Spencer. The perfection of his method, its application, and the uprooting of prejudices which stood in its way—this was the task to which Mr. Mill applied himself with an ability and success rarely matched and never surpassed.

HIS WORK IN POLITICAL ECONOMY

BY PROF. J. E. CAIRNES.

THE task of fairly estimating the value of Mr. Mill's achievements in political economy—and indeed the same remark applies to what he has done in every department of philosophy—is rendered particularly difficult by a circumstance which constitutes their principal merit. The character of his intellectual, no less than of his moral nature, led him to strive to connect his thoughts, whatever was the branch of knowledge at which he labored, with the previously existing body of speculation, to fit them into the same framework, and exhibit them as parts of the same scheme; so that it might be truly said of him that he was at more pains to conceal the originality and independent value of his contributions to the stock of knowledge than most writers are to set forth those qualities in their compositions. As a consequence of this, hasty readers of his works, while recognizing the comprehensiveness of his mind, have sometimes denied its originality; and in political economy in particular he has been frequently represented as little more than an expositor and popularizer of Ricardo. It cannot be denied that there is a show of truth in this representation; about as much as there would be in asserting that Laplace and Herschel were the expositors and popularizers of Newton, or that Faraday performed a like office for Sir Humphrey Davy. In truth, this is an incident of all progressive science. The cultivators in each age may, in a sense, be said to be the interpreters and popularizers of those who have preceded them; and it is in this sense, and in this sense only,

that this part can be attributed to Mill. In this respect he is to be strongly contrasted with the great majority of writers on political economy, who, on the strength, perhaps, of a verbal correction, or an unimportant qualification, of a received doctrine, if not on the score of a pure fallacy, would fain persuade us that they have achieved a revolution in economic doctrine, and that the entire science must be rebuilt from its foundation in conformity with their scheme. This sort of thing has done infinite mischief to the progress of economic science; and one of Mill's great merits is that both by example and by precept he steadily discountenanced it. His anxiety to affiliate his own speculations to those of his predecessors is a marked feature in all his philosophical works, and illustrates at once the modesty and comprehensiveness of his mind.

On some points, however, and these points of supreme importance, the contributions of Mill to economic science are very much more than developments—even though we understand that term in its largest sense—of any previous writer. No one can have studied political economy in the works of its earlier cultivators without being struck with the dreariness of the outlook which, in the main, it discloses for the human race. It seems to have been Ricardo's deliberate opinion that a substantial improvement in the condition of the mass of mankind was impossible. He considered it as the normal state of things that wages should be at the *minimum* requisite to support the laborer in physical health and strength, and to enable him to bring up a family large enough to supply the wants of the labor-market. A temporary improvement, indeed, as the consequence of expanding commerce and growing capital, he saw that there might be; but he held that the force of the principle of population was always powerful enough so to augment the supply of labor as to bring wages ever again down to the *minimum* point. So completely had this belief become a fixed idea in Ricardo's mind, that he confidently drew from it the consequence that in no case could taxation fall on the laborer, since—living, as a normal state of things, on the lowest possible stipend adequate to maintain him and his family—he would inevitably, he argued, transfer the burden to his employer, and a tax, nominally on wages, would, in the result, become invariably a tax upon profits. On this point Mill's doctrine leads to conclusions directly opposed to Ricardo's, and to those of most preceding economists. And it will illustrate his position, as a thinker, in relation to them, if we note how this result was obtained. Mill neither denied the premises nor disputed the logic of Ricardo's argument: he accepted both; and in particular he recognized fully the force of the principle of population; but he took account of a further premiss which Ricardo had overlooked, and which, duly weighed, led to a reversal of Ricardo's conclusion. The *minimum* of wages, even such as it exists in the case of the worst-paid laborer, is not the very least sum that human nature can subsist upon; it is

something more than this: in the case of all above the worst-paid class it is decidedly more. The *minimum* is, in truth, not a physical, but a moral *minimum*, and, as such, is capable of being altered with the changes in the moral character of those whom it affects. In a word, each class has a certain standard of comfort below which it will not consent to live, or, at least to multiply—a standard, however, not fixed, but liable to modification with the changing circumstances of society, and which in the case of a progressive community is, in point of fact, constantly rising, as moral and intellectual influences are brought more and more effectually to bear on the masses of the people. This was the new premiss brought by Mill to the elucidation of the wages question, and it sufficed to change the entire aspect of human life regarded from the point of view of Political Economy. The practical deductions made from it were set forth in the celebrated chapter on "The Future of the Industrial Classes"—a chapter which, it is no exaggeration to say, places a gulf between Mill and all who preceded him, and opens an entirely new vista to economic speculation.

The doctrine of the science with which Mill's name has been most prominently associated, within the last few years, is that which relates to the economic nature of land, and the consequences to which this should lead in practical legislation. It is very commonly believed that on this point Mill has started aside from the beaten highway of economic thought, and propounded views wholly at variance with those generally entertained by orthodox economists. No economist need be told that this is an entire mistake. In truth there is no portion of the economic field in which Mill's originality is less conspicuous than in that which deals with the land. His assertion of the peculiar nature of landed property, and again his doctrine as to the "unearned increment" of value arising from land with the growth of society, are simply direct deductions from Ricardo's theory of rent, and cannot be consistently denied by any one who accepts that theory. All that Mill has done here has been to point the application of principles, all but universally accepted, to the practical affairs of life. This is not the place to consider how far the plan proposed by him for this purpose is susceptible of practical realization; but it may at least be confidently stated that the scientific basis on which his proposal rests is no strange novelty invented by him, but simply a principle as fundamental and widely recognized as any within the range of the science of which it forms a part.

There is one more point which ought not to be omitted from even the most meagre summary. Mill was not the first to treat political economy as a science, but he was the first, if not to perceive, at least to enforce the lesson, that, just because it is a science, its conclusions carried with them no obligatory force with reference to human conduct. As a science it tells us that certain modes of action lead to certain results; but it remains for each man to judge of the value of the

results thus brought about, and to decide whether or not it is worth while to adopt the means necessary for their attainment. In the writings of the economists who preceded Mill it is very generally assumed that to prove that a certain course of conduct tends to the most rapid increase of wealth suffices to entail upon all who accept the argument the obligation of adopting the course which leads to this result. Mill absolutely repudiated this inference, and, while accepting the theoretic conclusion, held himself perfectly free to adopt in practice whatever course he preferred. It was not for political economy or for any science to say what are the ends most worthy of being pursued by human beings: the task of science is complete when it shows us the means by which the ends may be attained; but it is for each individual man to decide how far the end is desirable at the cost which its attainment involves. In a word, the sciences should be our servants, and not our masters. This was a lesson which Mill was the first to enforce, and by enforcing which he may be said to have emancipated economists from the thraldom of their own teaching. It is in no slight degree, through the constant recognition of its truth, that he has been enabled to divest of repulsiveness even the most abstract speculations, and to impart a glow of human interest to all that he has touched.

HIS INFLUENCE AT THE UNIVERSITIES.

BY PROF. FAWCETT.

SOME time ago, when there was no reason to suppose that we should so soon have to mourn the loss of the great thinker and of the kind friend who has just passed away, I had occasion to remark upon the influence which Mr. Mill had exercised at the universities. I will quote my words as they stand, because it is difficult to write with impartiality about one whose recent death we are deploring; and Mr. Mill would, I am sure, have been the first to say that it is certainly not honoring the memory of one who is dead to lavish upon him praise which would not be bestowed upon him if he were living. I will, therefore, repeat my words exactly as they were written two years since: "Any one who has resided during the last twenty years at either of our universities must have noticed that Mr. Mill is the author who has most powerfully influenced nearly all the young men of the greatest promise." In thus referring to the powerful influence exercised by Mr. Mill's works, I do not wish it to be supposed that this influence is to be measured by the extent to which his books form a part of the university *curriculum*. His "Logic" has no doubt become a standard examination-book at Oxford. At Cambridge, the Mathematical and Classical Triposes still retain their former *prestige*. The moral science tripos, though increasing in importance, still attracts a comparatively small number of students, and there is probably no other examination for which it is necessary to read Mr. Mill's "Logic" and "Political Economy." This fact

affords the most satisfactory evidence that the influence he has exerted is spontaneous, and is therefore likely to be lasting in its effects. If students had been driven to read his books by the necessity which examinations impose, it is quite possible that, after the examination, the books might never be looked at again. A resident, however, at the university can scarcely fail to be struck with the fact that many who perfectly well know that they will never in any examination be asked to answer a question in logic or political economy, are among the most diligent students of Mr. Mill's books. When I was an undergraduate I well remember that most of my friends who were likely to take high mathematical honors were already so intimately acquainted with Mr. Mill's writings, and were so much imbued with their spirit, that they might have been regarded as his disciples. Many looked up to him as their teacher; many have since felt that he then instilled into them principles which, to a great extent, have guided their conduct in after-life. Any one who is intimately acquainted with Mr. Mill's writings will readily understand how it is that they possess such peculiar attractiveness for the class of readers to whom I am now referring. There is nothing more characteristic in his writings than generosity and courage. He always states his opponent's case with the most judicial impartiality; he never shrinks from the expression of opinion because he thinks it unpopular, and there is nothing so abhorrent to him as that bigotry which prevents a man from appreciating what is just and true in the views of those who differ from him. This toleration, which is so predominant a feature of his writings, is probably one of the rarest of all qualities in a controversialist. Those who do not possess it always produce an impression that they are unfair; and this impression, once produced, exercises a repelling influence upon the young.

To those who believe that the influence Mr. Mill has exercised at the universities has been in the highest degree beneficial—to those who think that his books not only afford the most admirable intellectual training, but also are calculated to produce a most healthy moral influence—it may be some consolation, now that we are deploring his death, to know that, although he has passed away, he may still continue to be a teacher and a guide. I believe he never visited the English universities; it was consequently entirely through his books that he was known. Not one of those who were his greatest admirers at Cambridge, when I was an undergraduate, ever saw him till many years after they had left the university. Nothing, perhaps, was so remarkable in his character as his tenderness to the feelings of others, and the deference with which he listened to those in every respect inferior to himself. There never was a man who was more entirely free from that intellectual conceit which breeds disdain. Nothing is so discouraging and heart-breaking to young people as the sneer of an intellectual cynic. A sarcasm about an act of youthful mental en-

thusiasm not only often casts a fatal chill over the character, but is resented as an injury never to be forgiven. The most humble youth would have found in Mr. Mill the warmest and most kindly sympathy.

HIS POSITION AS A PHILOSOPHER.

BY W. A. HUNTER.

It is always hazardous to forecast the estimation in which any man will be held by posterity. In one sense truly we have no right to anticipate the judgment of the future, sufficient for us to form opinions satisfactory within the limits of our own generation. Sometimes, by evil chance, a great name is covered with undeserved reproach, and it is reserved for a distant future to do it justice. But, such a work as Mr. Carlyle did for Cromwell we may confidently anticipate will never be required for the name of John Stuart Mill. He is already enrolled among the first of contemporary thinkers, and from that list his name will never be erased. The nature of Mr. Mill's work is such as to make it easy to predict the character of his future reputation. His is the kind of philosophy that is destined to become the commonplace of the future. We may anticipate that many of his most remarkable views will become obsolete in the best sense, they will become worked up into practice, and embodied in institutions. Indeed, the place that he will hold, will probably be closely resembling that of the great father of English philosophy, John Locke. There is, indeed, amid distinguishing differences, a remarkable similarity between the two men, and the character of their influence on the world. What Locke was to the liberal movements of the seventeenth century, Mr. Mill has more than been to the liberal movement of the nineteenth century. The intellectual powers of the two men had much in common, and they were exercised upon precisely similar subjects. The "Essay on the Human Understanding" covered doubtless a field more purely psychological than the "Logic," but we must remember that the "Analysis of the Mind" by the elder Mill had recently carried the inductive study of mind to an advanced point. If, however, we regard less the topics on which these two illustrious men wrote, than the special service rendered by each of them to intellectual progress, we may not unfittingly compare the work of Locke—the descent from metaphysics to psychology—to the noble purpose of redeeming logic from the superstition of the Aristotelians, and exalting it to something higher than a mere verbal exercise for school-boys. The attack that Locke opened with such tremendous effect on the *a priori* school of philosophy was never more ably supported than by the "Logic" and controversial writings of Mr. Mill.

The remarkable fact in regard to both these great thinkers—these conquerors in the realms of abstract speculation—is their relation to politics. Locke was the political philosopher of the Revolution of 1688; Mr. Mill has been the political philosopher of the democracy

of the nineteenth century. The vast space that lies between their treatises represents a difference, not in the men, but in the times. Locke found opposed to the common weal an odious theory of arbitrary and absolute power. It is interesting to remember what were the giants necessary to be slain in those days. The titles of his first chapters on "Government" significantly attest the rudimentary condition of political philosophy in Locke's day. Adam was generally considered to have had a divine power of government, which was transmitted to a favored few of his descendants. Accordingly, Locke disposes of Adam's title to sovereignty, to whatever origin it may have been ascribed—to "creation," "donation," "the subjection of Eve," or "fatherhood." There is something almost ludicrous in discussing fundamental questions of government with reference to such Scriptural topics; and it is a striking evidence of the change that has passed over England since the Revolution, that, whereas Locke's argument looks like a commentary on the Bible, even the bishops now do not in Parliament quote the Bible on the question of marriage with a deceased wife's sister. Nevertheless, Locke clearly propounded the great principle which, in spite of many errors and much selfishness, has been the fruitful heritage of the Whig party. "Political power, then, I take to be a right of making laws with penalties of death, and consequently all less penalties, for the regulating and preserving of property and of employing the force of the community in the execution of such laws, and in the defence of the commonwealth from foreign injury, *and all this only for the public good.*" Locke also enounced the maxim that the state of Nature is one of equality. Mr. Mill's special views on the land-question are not without parallel in Locke, for that acute thinker distinctly laid down that "labor" was the true ground even of property in land. Still it must be confessed that Locke's political philosophy is much cruder than Mr. Mill's. His "Essay on Government" is as the rough work of a boy of genius, the "Representative Government" a finished work of art of the experienced master. And this difference corresponds with the rate of political progress. The English constitution, as we now understand it, was unknown at the Revolution; it had to be slowly created; now the great task of the future is to raise the mass of the people to a higher standard of political intelligence and material comfort. To that great end no man has contributed so much as Mr. Mill.

Perhaps, the one writing for which above all others Mr. Mill's disciples will love his memory, is his essay "On Liberty." In this undertaking Mr. Mill followed the noble precedent of Locke, with greater largeness of view, and perfection of work. Locke's four letters "Concerning Toleration" constitute a splendid manifesto of the Liberals of the seventeenth century. The principle that the ends of political society are life, health, liberty, and immunity from harm, and not the salvation of souls, has taken nearly two centuries to root itself in

English law, but has long been recognized by all but the shallowest bigots. And yet Locke spoke of "atheism being a crime, which, for its madness as well as guilt, ought to shut a man out of all sober and civil society." Here, again, what a stride does the *Liberty* make? It is, once more, the difference of the times, rather than of the men. The same noble and prescient insight into the springs of national greatness and social progress characterizes the work of both men, but in what different measures! Again, we must say, the disciple is greater than the master. Closely bearing on this topic, is the relation of the two men to Christianity. Locke not only wrote to show the "Reasonableness of Christianity," but paraphrased several of the books of the New Testament. Mr. Mill has never written one sentence to give the least encouragement to Christianity. But, although a contrast appears to exist, there is really none. Locke was what may be called a Bible Christian. He rejected all theological systems, and constructed his religious belief in the truly Protestant way, with the Bible and his inner consciousness. His creed was the Bible as conformed to reason; but he never doubted which, in the event of a conflict, ought to give way. To him the destructive criticism of biblical scholars, and the discoveries of geology, had given no disquietude; and he died with the happy conviction that, without abandoning his religious teaching, he could remain faithful to Reason. Mr. Mill inherited a vast controversy; and he had to make a choice: like Locke, he remained faithful only to Reason.

Perhaps, it might be urged, this comparison leaves out of account the very greatest work of Mr. Mill—his "Political Economy." Locke lived too soon to be an Adam Smith; but, curiously enough, the parallel is not broken even at this point. In 1691, and again in 1695, he wrote: "Some considerations of the consequences of the lowering of interest, and raising the value of money," in which he propounded, among other views, that "taxes, however contrived, and out of whose hands soever immediately taken, do, in a country where the great fund is in land, for the most part terminate upon land." There is of course no comparison between the two men on this head; nevertheless it is interesting to note in prototype the germs of the great work of Mr. Mill. It shows the remarkable, and by no means accidental, similarity between the men.

This parallel is already too much drawn out; otherwise it would be worth observing on the characters and lives of these two men. Enough, however, has been said to show that we may not unreasonably anticipate for Mr. Mill a future such as has fallen to Locke. His wisdom will be the commonplace of other times; his theories will be realized in political institutions; and we may hope and believe the working-class will rise to such a standard of wealth, and culture, and political power, as to realize the generous aspirations of one of England's greatest sons.

EDITOR'S TABLE.

GEOGRAPHY IN SCHOOLS.

WHILE there is great ado about methods in teaching this subject, and the "battle of the geographies" waxes fierce before the school boards, but few stop to inquire into the real claims of the study, and he who should venture to say that it has no business in schools at all, that it usurps time which had better be given to other things, and is of very low value as a means of mental cultivation, would be regarded as absurd. Yet such an idea is entertained by many thoughtful persons, and it increases in force as our educational system is more closely scrutinized.

In his celebrated inaugural address, at the University of St. Andrews, Mr. J. S. Mill remarked: "It has always seemed to me a great absurdity that history and geography should be taught in schools; except in elementary schools for children of the laboring-classes, whose subsequent access to books is limited. Who ever really learned history and geography except by private reading? and, what an utter failure a system of education must be, if it has not given the pupil a sufficient taste for reading, to seek for himself those most attractive and easily intelligible of all kinds of knowledge! Besides, such history and geography as can be taught in schools, exercise none of the faculties of intelligence, except memory."

If this very decisive verdict be thought merely the opinion of a theorist, it is easy to reënforce it by the judgment of practical men who speak from experience in the management of schools. A committee on "Text-books, and a Graded Course of Instruction," of the public schools of Milwaukee, in their report to the board of School Commissioners on the study of geography, say: "The committee have given the subject full and careful consideration, and have come to the conclusion that the study of geography, as now pursued in our schools, should be radically changed. Considering the time devoted to it, and the application required, we are of the opinion that no study is productive of results so meagre and unsatisfactory. It will not be contended that much is to be gained in the way of mental discipline from geography as taught in this city, and we might as well say generally throughout this country. The same amount of time and labor, bestowed upon many other branches of knowledge, would do a great deal more for development of the faculties of the mind. About the only positive result obtained is, storing the memory with an array of disconnected facts, which may indeed be made available in astonishing visitors at examinations, but are utterly useless as a means of unfolding the thinking powers. Nay, more, the very object of the study is defeated by the methods of instruction commonly in use. It is possible to find whole classes of pupils who have spent several years in 'learning geography,' and who can answer endless columns of questions in locating places; but who can in no sense be said to have acquired the knowledge which geography—rightly understood—is intended to impart."

They remark further: "The committee are of opinion that altogether *too much time* is devoted to geography in our schools. It seems to us that a sufficient knowledge of the subject might be acquired by considerably abridging the number of lessons, and giving the time to studies of at least equal importance, which are now sacrificed to make room for the geography recitations. A com-

petent knowledge of our own language is surely one of the leading objects of the most common education. We are of opinion that our course of instruction in the English language is altogether too limited in its scope and imperfect in its methods. This should include something more than reading, spelling, grammar, and an occasional composition. The language, in its elements and structure, should be taught on scientific principles, so far as they have been ascertained, and the power to use it in speaking and writing, not only correctly but elegantly, systematically *developed* from the lowest to the highest grade. Then, again, no course of instruction—however elementary—can in our day be said to be complete, which does not aim to cultivate some acquaintance with the leading outlines of natural science; and we are persuaded that, in the more advanced grades at least, a portion of the time at present given to geography might be advantageously devoted to giving instruction in botany, zoology, physics, and astronomy, by oral lessons of a simple and elementary nature."

Mr. Mill says that geography exercises none of the powers of intelligence, except the memory, and the committee declare that it does this badly; and both, we think, are right. Loading the memory with an array of arbitrary and disconnected facts is not the proper method of cultivating it. The true office of this faculty is, to be the servant of the other faculties. It is the power which recovers for present use the mind's past acquisitions. But the power of recalling past impressions rests upon the law of association, and rational memory depends upon the relations subsisting among the mental impressions. If knowledge has been digested, and the relations among its objects seen, their recovery in thought is easy and natural; but, where the other faculties are neglected, the memory is merely burdened with arbitrary statements, and only those things are remembered that are burnt into it by interminable repetition. Dr. Arnold reprobates the ordinary school-method of treating geography, and commends the point of view here indicated. He says: "And this deeper knowledge becomes far easier to remember. For my own part, I find it extremely difficult to remember the positions of towns, when I have no other association with them than their situations relatively to each other. But let me once understand the real geography of a country—its organic structure, if I may so call it; the outline of its skeleton, that is, of its hills; the magnitude and course of its veins and arteries, that is, of its streams and rivers; let me conceive of it as a whole made up of connected parts; and then the positions of towns, viewed in reference to these parts, become at once easily remembered, and lively and intelligible besides."

The objection to teaching geography to the young is, that its entire subject matter is beyond the sphere of experience; it is, therefore, much less fit to be used as a means of mental cultivation than many other subjects. Geography deals with an order of ideas which it is extremely difficult for the adult mind to grasp in their true relations, and impossible for the minds of children. "Geography is a description of the earth," and, to begin with, the earth is "a vast globe, or ball." Now, a child may have a correct conception of a ball, which it gets from experience, but it has no conception from experience which will help it to a true idea of what is meant by "25,000 miles in circumference." The notion is utterly beyond its grasp, and, so far from KNOWING the fact, or forming any just mental view of it, it is merely cheated with words. And so it is with the attempt to conceive the extent and relations of the great continental and

oceanic tracts of the globe, or of its minor subdivisions into zones and countries, or of its great mountain and river systems. Into all these phenomena there enter an element of vastness, a magnitude of relations, and a scale of diversities, which are little more to the childish mind than if they were described to it in a language not understood. Maps, of course, are helpful, but they are only symbols which the pupil is incompetent to translate into reality. It matters nothing that all the statements of geography may be true; they are true to the pupil only as verbal statements made on authority. All that it can do is to memorize words of description, which is the lowest and most worthless work of education. An English gentleman, who was once riding on horseback in the country, was accosted by a boy, who offered, for a penny, to tell him all the capitals of Europe. When he had done, the gentleman replied, "Here is your penny, and I will give you another if you will tell me whether they are animals or vegetables." "Animals," replied the boy, promptly. This is, no doubt, an extreme case; but it illustrates what is very generally true in the school-study of geography—that the pupils have no adequate ideas of what the words mean.

The difficulty with geography is, that it does not rouse children to think, and cannot furnish them with materials for the exercise of reason and judgment, because, for this purpose, the things reasoned about require to be immediately accessible to thought. Without going so far as Mr. Mill, who declares geography in schools to be an absurdity, we are profoundly convinced that the current teaching of it to young pupils *is* absurd. It should be postponed to the later stages of study, when the mind has attained a considerable degree of maturity, and then, by means of globes, a general conception of the great features of the earth may be acquired. This will form a suitable preparation for that subsequent reading upon the subject which Mr. Mill suggests.

SCIENTIFIC EDUCATION IN THE FAR WEST.

We spoke, in the June number of The Popular Science Monthly, of the advantages that would arise from connecting the scientific exploration of the several States with their higher educational institutions. We have been since reminded that this is an accomplished fact in at least one of the States, and we hasten to give credit to Minnesota for having taken this new departure in scientific education. It is one of the youngest States in the Union, and a generation ago was but a land of savages, an indefinite tract in the great "Northwest Territory" beyond "Ouisconsin," beyond the distant Mississippi, that we now see taking the lead of the older States in organizing the new education by devoting her university to the comprehensive and practical study of Nature. This step has been but recently taken, and its benefits are prospective; but, if thoroughly carried out, there can be but little question of the advantages that must arise to the people of the State. By a law of 1872, to provide for the geological and natural-history survey of the State, the Board of Regents of the University of Minnesota were charged with the duty of organizing the work, and the Professors of Geology, Chemistry, Botany, and Zoology, of that institution, are the chief officers in carrying on the investigations in these departments, while money appropriations and land-grants are liberally voted to sustain the work, which is broadly laid out and clearly defined.

There is to be "a complete account of the mineral kingdom as represented in the State, including the number, order, dip, and magnitude, of the several geological strata, their richness in ores,

coals, clays, peats, salines, and mineral waters, marls, cements, building-stones, and other useful materials, the value of said substances for economical purposes and their accessibility; also an accurate chemical analysis of the various rocks, soils, ores, clays, peats, marls, and other mineral substances, of which complete and exact records shall be made."

The natural-history survey will "include, first, an examination of the vegetable productions of the State, embracing all trees, shrubs, herbs, and grasses, native or naturalized in the State; second, a complete and scientific account of the animal kingdom as properly represented in the State, including all mammalia, fishes, reptiles, birds, and insects."

There is also to be a meteorological investigation of the climate of the State, barometrical and thermometrical observations and measurements of elevations and depressions of the land, with a view to the formation of an authentic map.

It will be a part of the work to collect specimens of "all rocks, soils, ores, coals, fossils, cements, building-stones, plants, woods, skins, and skeletons, of animals, birds, insects, and fishes, and other mineral, vegetable, and animal substances and organisms discovered or examined in the course of said surveys, to be preserved for public inspection, free of cost, in the University of Minnesota, in rooms convenient of access and properly warmed, lighted, ventilated, and furnished, and in charge of a proper scientific curator; and they shall also, whenever the same may be practicable, cause duplicates, in reasonable numbers and quantities, of the above-named specimens to be collected and preserved for the purpose of exchanges with other State universities and scientific institutions."

The movement in this case, it is evident, has been initiated mainly in the interest of the geological survey, but it is to be hoped that the larger objects of education to which it is a means will not be lost sight of. The university will undoubtedly be benefited by taking the responsibility of the work, but the movement will fall greatly short of the good it might accomplish if it is not vitally connected with the educational system of the State. In the cities of Minnesota are growing up numerous normal schools and high-schools, which have a right to share in the general benefits of the undertaking. The specimens obtained by the several departments of the survey are to be collected in the University Museum at St. Anthony, and we are told that duplicates will be exchanged with other State universities and with scientific societies. But should not the claims of the people of the State be considered first, and should not the local schools be furnished with materials for cabinets representing the resources of their own State, and be encouraged to contribute something toward the general object by observations and collections in their own districts? We should be glad to see this element incorporated in the Minnesota experiment.

LITERARY NOTICES.

INTERNATIONAL SCIENTIFIC SERIES, No. III. ON FOODS. By EDWARD SMITH, M. D., F. R. S. D. Appleton & Co.

A GOOD, popular book on foods has long been wanted, and, as the object of the *International Scientific Series* is to furnish valuable and instructive reading for the general public, this subject was early provided for by securing the best authority in England to treat it. Dr. Smith is well and widely known by his extensive course of physiological experiments on the influence of foods and alcoholic liquors upon the human system, published in the "Philosophical Transactions" in 1859; by his official work as government inspector of practical dietaries for hospitals and almshouses; and by his various publications upon the subject of food and diet. A new work was, how-

ever, required, that should give the latest scientific information respecting foods, so clearly and simply written as to be understood by common people, and that should combine fulness of statement with compactness of form and a moderate price. Dr. Smith has realized these difficult conditions in a very remarkable degree in the volume now prepared. Adopting a classification that is recommended by its simplicity, he goes over the whole field and describes the properties, composition, preparations, and adaptations of all the alimentary substances now employed by civilized man. In his preface, the author remarks: "Largely-increased commercial intercourse with distant countries, associated with a marked improvement in the purchasing power of the masses of the people, and the rapid increase of wealth generally, have attracted public attention to the subject of foods and dietaries in an unusual degree, so that not only is there a greater importation of foreign productions than formerly, but new foods, or preparations of foods, are produced almost daily, some of which are specially fitted for certain classes of persons, as children, while others are of general use. Hence our food-supplies, whether natural or prepared, offer increased variety of flavor, if not of nutritive qualities, and foods which were formerly restricted to the few are now commonly found on the tables of the many.

"Scientific research in every civilized nation has also diligently busied itself in the elucidation of the subject, and our knowledge has been increased in reference to the chemical composition, preparation, and physiological effects of food.

"With so many causes of change since the issue of my work on 'Practical Dietary,' it seemed desirable to produce another which should embrace all the generally known and some less known foods, and contain the latest scientific knowledge respecting them, while at the same time the subject should be treated in a popular manner.

"It was originally intended to include both foods and diets in one work, but the subject has now become so large that it was found necessary to limit the present volume to foods alone, and to reserve the subject of diets and dietaries for a future occasion."

The amount of information that Dr. Smith has contrived to compress into this little volume is quite surprising; it seems, indeed, to have the completeness of a regular cyclopædia of the subject. Besides giving the pith of what is known of the whole range of aliments proper, simple and compound, he includes those outlying groups of bodies which, whether or not they be properly foods, are habitually taken into the system, and have great physiological importance. The properties of water, of air, of wines and spirituous liquors, are well summed up in their relations to the living organism. The volume contains many illustrations and valuable tables, with full-page diagrams, representing graphically the effects of various alimentary agents upon the system in different times and circumstances. Dr. Smith's work will be a standard manual upon the important subject of foods.

THEORETICAL NAVIGATION AND NAUTICAL ASTRONOMY. By LEWIS CLARK, Lieutenant-Commander U. S. N. New York: D. Van Nostrand, 1872.

THIS is a book written, as the introduction informs us, "for use at the United States Naval Academy." It is, then, intended to be used by young pupils as a first book, and must be judged by the rules which apply to the ordinary text-book: that is to say, it must be, before all things, clear, eminently accurate, and it must be calculated to develop in the student a habit of exactness; and, since it is a text-book of so practical a subject as navigation, it must be a book of reference which the graduated midshipman can safely use. These are the tests which any one, who writes a book on navigation and nautical astronomy, must attempt to satisfy, and which, it seems, should be easily satisfied, since the subject is an old one, and since such a writer has many works of able predecessors to consult.

These conditions this volume in no wise fulfils. Indeed, its author tells us, in the early portions of his book, that, in the work of interpolating from the "Nautical Almanac," formulæ have been given to meet each

particular case. The author has found that, in general, they are of no practical assistance to the student, and even in some cases [are] confusing."

How an interpolation is to be made unless by the aid of a formula, the author does not tell us, although the mind naturally is anxious upon so important a point.

He goes on to add a practical precept, however, to the effect that he desires to impress upon the student the importance of obtaining the Greenwich time "almost invariably" before consulting the "Almanac." As the "Nautical Almanac" is so constructed that no element can be taken from it *without* a knowledge of the Greenwich time, it seems almost a work of supererogation to "impress" this fact at the 26th page of a work on navigation.

But, allowing these two practical precepts to stand as examples of the conclusions which the author's experience at sea has led him to, let us briefly notice some of the more important features of the early portions of the treatise, remarking that, to fulfil its purpose as a suitable text-book, these should be exact and clear; and, further, remembering that it is important that the interests of the student should be sedulously guarded, and that his first ideas should be of the most definite nature and *strictly* correct.

Let us remember, too, that a very poor book, of no peculiar importance in itself, has a claim to notice in an educational point of view. There is hardly a middle ground between goodness and badness in such a one: if it be good, let us have it by all means; if bad, it is a duty to warn others against it.

Perhaps there is nothing more important to the navigator than a clear conception of the astronomical ideas of time, latitude, and longitude. "Longitude," says our author, "is the angular distance between any meridian and a fixed or prime meridian. It may be considered as an angle at the pole," etc.

Longitude of what? Any definition of longitude should begin, "*the* longitude of a place is," etc. There is no abstract thing called longitude; but there is a certain definite coördinate for every point on the earth's surface, which is the object of the definition. The same objection applies to the definition of latitude.

On page 18 we learn that "time is the hour-angle of some heavenly body, whose apparent diurnal motion is taken as a measure." Now, there is such a thing as time in the abstract, portions of which we measure, or have measured for us, by certain recurring phenomena.

The explanations of apparent time and of the equation of time are equally faulty; but imagine the surprise of the astronomer, who is told that "astronomical time *commences* at noon, and *is measured toward the westward!*"

From this, to measuring eternity toward the northeast, is but a step. It is evident that, in the author's mind, the words "time" and "day" were equivalent.

With these fundamental errors in the book, it is scarcely probable that it should not be faulty in other ways. And, indeed, it will be found in many points inaccurate, confused, often unintelligible. Perhaps it is hardly necessary to mention certain other faults of the book, which are still discreditable. Many of its demonstrations are taken directly from other text-books, and in no instance, we believe, is a proper acknowledgment made. Its chapter on the Compass is reprinted, almost *verbatim*, from a pamphlet published by the Navy Department on the same subject, and, although the author probably meant to do no injustice, no mention is made of this fact in any way.

On the whole, we must set this down as a harmful book, being full of doubtful statements, of confused mathematics and questionable precepts, and one not likely to improve the art of navigation, or the science of nautical astronomy, in any way.

THE COAL-REGIONS OF AMERICA: their Topography, Geology, and Development. By JAMES MACFARLANE, A. M. 8vo, 679 pages. New York: D. Appleton & Co.

THOSE who understand how closely our coal-resources are linked to the future prosperity of the nation, and how completely, even now, they are involved with the great elements of manufactures, commerce, and locomotion, will appreciate the value of a comprehensive and fully-illustrated work

upon the subject, brought up to the present time. The book aims to be a sort of "encyclopedia of all that is known on the subject that is permanently important and valuable." Government has done a good deal to explore this subject in the several States, but the ponderous volumes of reports they have published are expensive, inaccessible, and require to be digested in the cheap and popular form of a convenient hand-book. For the benefit of those who have but little knowledge in geology, some general information is given on the origin of coal-beds, and their place among the rocky strata, which is applicable to all the coal-regions. Besides the special descriptions of the coal-resources of each State, there is a chapter on the iron-ores of the coal-measures, one on the combustion of coal, and one giving the latest statistics of coal-mines in the United States and in foreign countries. There is also a very valuable chapter on the conditions of success in the coal-trade. The volume is enriched by a contribution from Prof. Newberry on the coal-strata of Ohio, and the author acknowledges important assistance from Profs. Cox, Worthen, White, and Foster. Mr. Macfarlane's work is altogether of a very practical character, and will form an instructive contribution to the literature of the subject.

LIBERTY, EQUALITY, FRATERNITY. By JAMES FITZJAMES STEPHEN, Q. C. Holt & Williams.

THIS is a refreshing book, and is bound to set a good many people thinking. Its contents appeared as a series of anonymous essays in the *Pall Mall Gazette*, and attracted much attention by the forcible manner in which they were written, and the boldness and ability with which they challenged the "liberal tendencies" of English thought. The author takes Mr. Mill as the representative and authoritative expositor of these tendencies, and subjects several of his works to a merciless dissection. Acknowledging his indebtedness to Mr. Mill as the author of the "Logic" and the "Political Economy," he utterly repudiates the doctrines advocated in the "Liberty" and the "Subjection of Woman." The readers of THE POPULAR SCIENCE MONTHLY have had a sample of his method in the article on the "Equality of the Sexes," in the March number, in which he criticised Mr. Mill's main positions upon this subject. In the other essays he takes up the prevailing democratic tendencies as embodied in the phrase "liberty, equality, and fraternity," and deals with them in the same unsparing manner. His book is a plea for social restraints, and a protest against those interpretations of liberty which would make it consist in exemption from restraining agencies. Mr. Stephen exercises the largest liberty of criticism, and writes with the fire of a partisan; but his book abounds with fresh and pregnant suggestions, and its wide circulation will exert a wholesome influence in this country

CALIBAN: The Missing Link. By DANIEL WILSON, LL. D. New York: Macmillan & Co.

THIS volume is another added to the very considerable list of recent books designed to illustrate the omniscience of Shakespeare. Prof. Wilson thinks that he anticipated the modern doctrine of evolution, and in his character of *Caliban* has delineated the characteristics of the creature Mr. Darwin is in search of, namely, "the missing link between man and beast." The book abounds in extracts from Shakespeare's works, and ingenious interpretations of them, but is vague in its argument, and any thing but satisfactory in its conclusions.

THE AMERICAN CHEMIST: A Monthly Journal of Theoretical, Analytical, and Technical Chemistry. Edited by CHARLES F. CHANDLER, Ph. D., Professor of Analytical and Applied Chemistry in the School of Mines, Columbia College, New York, and WM. H. CHANDLER, F. C. S., Professor of Chemistry in the Lehigh University, Bethlehem, Pa. Philadelphia: H. C. Lea.

WE have before us vols. i. and ii. (new series) of this valuable monthly, and a careful examination of their contents leads us to recommend it very strongly to public attention. It is edited with skill and judgment, contains a large amount of important information nowhere else so accessible, and deserves a liberal and remunerative patronage. The great science of chemistry, we might almost say, is at the bottom of every

thing that is going on in this world. It underlies agriculture; it is the basis of manufactures; it is the key to geology; meteorology depends upon it; it explains domestic processes; is the foundation of physiology and biology, and, moreover, astronomy has lately courted its alliance, and arrived at the most splendid results by its aid. Certainly a magazine which chronicles the progress of this most progressive of the sciences should have a vigorous support, while the reputation of its accomplished editors is the best guarantee of its trustworthy character.

MISCELLANY.

The New Planet Vulcan.—The observation of certain disturbances in the motion of the planet Mercury, and the appearance at particular periods of well-defined circular black spots, passing rapidly across the disk of the sun, have led astronomers to suspect the existence of a ninth planet, interior to Mercury, and with a period of revolution, according to M. Leverrier, of 19.70 days. Such a spot was seen to cross the sun on March 26, 1859, the observer being a French physician named Lescarbault, who thereupon claimed the discovery of the planet, to which the name of Vulcan was assigned. It should be added, however, that other observers had previously witnessed a similar phenomenon. The spot was again seen by Mr. Lummis, of Manchester, on the 20th of March, 1862. From calculations based upon these and other observations, Mr. Hind, of the Twickenham Observatory, England, in a letter last year to the London *Times*, suggested 10 o'clock A. M. on the 24th of March, 1873, as the time when a conjunction of the supposed planet with the sun might be expected to occur. "If the hypothetical body," says Mr. Hind, "is not found upon the sun's disk at that time, it will be, I think, a sufficient proof that my surmises are incorrect." Prof. Kirkwood, in a recent letter to the *Tribune*, states that "Mr. Cowie has just reported the appearance of such a spot on the sun at Shanghai, China, on the morning of March 24, 1873, thus fulfilling the prediction of Mr. Hind, and rendering the existence of such a planet reasonably certain. Prof. Kirkwood's calculations, as given in the letter above quoted, make its sidereal period 34 days, 22 hours, 31 minutes. In a subsequent letter, Prof. Kirkwood calls attention to the fact that similar spots have been observed on the sun, at other dates, which cannot be referred to the same asteroid, and he thence infers the existence of a zone of minor planets within the orbit of Mercury. Why none of these have ever been seen during total eclipses of the sun he explains as follows:

"It is well known that a marked difference obtains between the light-reflecting capacities of the various planets of our system. Mercury, for instance, is in this respect very much inferior to Venus and Jupiter. (*See* Proctor's "Other Worlds than Ours," p. 67.) The difficulty, then, in regard to the invisibility of these asteroids when the sun is eclipsed, may be obviated by supposing their surfaces so constituted as to reflect but a small portion of the sun's light."

Education in Sierra Leone.—Mr. John Pope Hennessy, ex-Governor of Sierra Leone, delivered recently, before the London Society of Arts, an admirable lecture on "the British Settlements in Western Africa." We give a synopsis of that part of the discourse which treated of the state of education. It is the avowed purpose of the British Government to train the natives to habits of self-control, so that they may be finally suffered to govern the country themselves. But that no great progress has been made in the preliminary work of education is admitted on all sides. In 1869, "education was most inadequately provided for" in Sierra Leone. In 1870 the "conspicuous listlessness and inattention of the scholars" are noted by the Director of Public Instruction. In 1872 Mr. Hennessy was himself convinced that the system in use was only "an incentive to the formation of a thoughtless, idle, and indolent character." And at Cape Coast matters were still more unpromising. In 1872 the government chaplain calls loudly for compulsory education, because he cannot induce the scholars to attend to their duties.

That the fault does not lie with the natives is very satisfactorily shown by Mr. Hennessy. On his second visit to Lagos,

King Docemo told him that all his chiefs and principal people were most desirous of having their children educated, but they did not want their religious ideas to be interfered with. The king's own son was obliged to quit a school under English control, being unwilling to believe in the teachers' "mission to enlighten the natives in matters of religion." *All* the "chiefs and captains of companies" at Cape Coast assured Governor Hennessy that "they would give any thing for a good education;" but their religion must not be interfered with. A few low-caste natives, they said, in hopes of promotion to clerkships and catechistships, would continue to frequent the English schools; but the only result would be "flagrant hypocrisy and idleness."

The same testimony was given by all the native chiefs whom Mr. Hennessy met. Bey Inca, King of the Small Scarcies, had sent his son to the Portuguese settlements, to learn Arabic and Portuguese, and he was about sending him now to Senegal, to learn French, and to complete his Arabic. That youth would one day be the ruler of a country on the border of the British settlement of Sierra Leone, and yet he would be ignorant of the English language—a thing deeply to be regretted, thought King Inca.

Purification of Bone-Black.—The refined bone-black of commerce is seldom possessed of the qualities usually ascribed to it. Its decolorizing properties are weak, and, besides, it always contains sulphate of lime, which dissolves in the liquids to be clarified. Herr Gräger, in *Dingler's Journal*, gives the following process for purifying bone-black: It is to be ground to powder, and then boiled in from four to six times its weight of water, containing 4 or 5 per cent. of carbonate of soda. After standing four days, the water is drawn off, and hot water poured on instead. This having been in turn drawn off, the bone-black is next treated with commercial chlorhydric acid, and again heated. The latter treatment is followed until the liquid is no longer turbid from the presence of ammonia. The amount of acid to be used is much greater than is commonly supposed. The next step is to wash with common water, to filter with distilled water, and to dry the bone-black at a temperature of from 212° to 248° Fahr. One hundred parts of crude bone-black yield 20 parts refined. The product is a light powder, very fine, with intense decolorizing power, and but a small quantity need be used to produce the required effect.

The Mistletoe.—The following, over the signature of R. W. Newberry, occurs in the *New York World:* "About last Christmas-time I noticed on two occasions in the *World* that the existence of the 'mistletoe' in this country was doubted. I knew of its existence, but didn't want to make the assertion till I had the proof, which I enclose herewith. I found it on Staten Island many years ago growing on pepperidge-trees. In Maryland it affects the same tree, and also the oak. There is plenty in Virginia, and the specimen I send you was collected from a persimmon-tree at the Bangle Gold-Mine, near Concord, Cabarrus County, N. C., which place I had occasion to visit last week. The number of days it has been gathered and the journey have rather spoiled the sample."

Prof. S. Lockwood says that the false, or American Mistletoe, used to be found on the *Nyssa multiflora*, the pepperidge, or gum-tree, in Mercer County, N. J., which probably is its northern limit in the Eastern States. Buf this is not the true mistletoe of Europe, which belongs to the genus *Viscum*. The American parasite is the *Phoradendron flavescens*. It infests a number of the deciduous trees, and almost covers some of the oak-trees in Plaquemine Parish, La. The professor says that he received specimens in full bloom, last January, from that locality.

The statements of the Torrey Botanical Club, in regard to certain illusions concerning the English mistletoe, will be interesting in this connection. The idea that the English plant is limited to the oak is an error, it being believed that it is not to be found on more than three oak-trees in all Great Britain. There are but few people in England that have seen it grow at all, and they have generally found it on the apple and wild-crab trees. And yet, as a decoration, with holly, ivy, and laurel, it abounds at Christmas, and is bought with these plants at twopence a bunch. This genuine English mis-

tletoe, under which the girls are kissed in the Christmas-games, is a sort of "pious fraud," being imported in enormous quantities into England from Belgium in immense crates. In Belgium it is plentiful on old and exhausted apple-trees. Indeed, the real Druid mistletoe of the English oaks has become almost like that ancient personage, a thing of the past.

A Viviparous Fly.—In the *American Naturalist* is an interesting account, by Prof. Lockwood, of the *Sarcophaga carnaria*, a species of flesh-fly, which brings forth its larvæ or maggots alive, instead of laying eggs. Fine engravings are given of the fly, its pupa, and larva. The professor succeeded in rearing some of the grubs until they became perfect flies, it requiring 13 days to effect the complete series of changes. One of the grubs he put alive into 95 per cent. alcohol, in which fluid it sustained life 134 minutes. This larva was six days old. One seven days old was placed in turpentine, where motion ceased only at the end of 27 minutes. One in essence of peppermint lived 70 minutes; and another, in Fowler's solution, only ceased to manifest motion at the end of 53 minutes.

From these experiments Dr. Lockwood is led to remark: "In the light of such facts, what reprobation is too severe upon the useless and cruel practice of drenching horses with violent medicaments for the bots? The ailment thus known is due to the presence in the animal's stomach of the larvæ of the bot-fly (*Gastrophilus equi*), which clings to the walls of the stomach by its formidable mouth-hooks." As further evidence of the tenacity of life of the larvæ of certain flies, this naturalist says: "Long ago my attention was called to the tenacity of larval life when exposed to poisons. I was forced by the claims of justice to take part in a toxicological examination of the internal organs of a person who had been nine months buried. These were put in a large glass jar, and the jar filled with water. It was summer. A small portion of the viscera rose above the fluid. In three or four days, I noticed the presence of a great number of large white larvæ, doubtless of the common blow-fly. We obtained enough bichloride of mercury to establish the fact that the woman had died by taking a very large quantity of this terrible poison. Naturalists know how well this drug will preserve animal tissues. And, in this case, the blood in the capillary vessels was of a bright color, as if fresh. And, despite the presence of so much poison, the larvæ grew. Whether they would change to flies, I cannot say. Another case is that of the horse of a friend, which was injured by accident and had to be killed. The animal was opened, and the walls of the stomach were found to be covered with the larvæ of the bot-fly. A piece of the stomach was spread on a board in the sun. Some turpentine was poured on the larvæ, with but little effect, as not one was detached, when it was examined an hour afterward. Some whale-oil was then poured on them. They let go immediately, and soon all died."

This subject of the tenacity of life in insects has lately engaged the attention of the Belgian naturalist, Plateau. We give his more important results. At the bottom of an open vessel holding a little over a quart of fresh water he placed a very small vessel containing the insect, and covered with a piece of cotton netting. Terrestrial insects placed in these conditions, impelled by their specific lightness, rise to the lower surface of the net-work. The movements of their legs soon cease, they do not appear to suffer, and quickly grow torpid. The aquatic *Coleoptera* and *Hemiptera*, on the contrary, instead of submitting passively to their fate, endeavor to quit their prison, swim rapidly about, try to come to the surface, and so struggle on till they are quite exhausted and lie at the bottom as if dead.

M. Plateau, after keeping the insects thus under water for a certain length of time, took them out and dried them on blotting-paper. He found that the terrestrial *Coleoptera* recovered after immersion, in several instances, for 96 hours, while the aquatic swimming *Coleoptera* and *Hemiptera* had no such power of resistance to asphyxia. The author accounts for this by the rapid waste of oxygen caused by the greater activity of the aquatic insects. He also tried the effects of cold and heat on aquatic insects. It was found that these insects, in the latitude of Belgium, can live

for an indefinite period in water at the temperature of melting ice; but that they cannot remain alive in ice itself for half an hour. This he accounts for by the fact that in ice the insects are entirely deprived of all power of motion, thereby losing completely their animal heat. The author finds that the highest temperature which fresh-water spiders can endure, without injury, oscillates between 33°.5 and 46°.2 Cent. Comparing this with the results of experiments made on animals belonging to other groups, M. Plateau's conclusion is, that the highest temperature endurable by aquatic vertebrates, articulates, and mollusks, does not exceed 46° Centigrade.

Parthenogenesis in Shrimps.—The *Apus cancriformis*, or crab-shield shrimp, has no less than 60 pairs of feet, each made up of an almost incredible number of joints. A German naturalist of the last century, Schaeffer, counted the joints in one of these animals, and found them to number almost 2,000,000. Friedrich Brauer, of the Vienna Academy of Sciences, has lately been studying the process of reproduction of these animals; and he finds that from the unfecundated eggs of the female spring females only, while the fecundated eggs produce only males. The experiments on the reproduction of the females extended over three generations. He also finds that the male *Apus* has one footless ring more than the female. With regard to parthenogenesis, or the production of offspring from unfecundated eggs, C. Vogt, in the course of an address before the Swiss Society of Natural Science, stated that he observed it in another crustacean of the same order as the *Apus*, namely, the *Artemia salina*, or brine-shrimp.

A Blood-sucking Squirrel.—Mr. Thomas G. Gentry recently reported to the Philadelphia Academy of Sciences the observation of a notable change of habit in a common red squirrel. Having had his attention called to the circumstance that the birds in a certain locality of Mount Airy were being rapidly killed off in the night-time, he found, on going to the spot, that the author of the slaughter was a chickaree, or common red squirrel, which he caught in the very act of sucking the blood of one of its innocent victims. Mr. Gentry states that, with at most two exceptions, the *Rodentia* subsist principally or entirely upon vegetable matter, especially the hard parts of plants, such as nuts, bark, and roots; and he thinks that the taste for blood shown in this instance may have arisen from the habit which some squirrels have of sucking the eggs of birds. "This adoption of another's mode of life by S. Hudsonius, he thought a discovery of some note, as usurpation of habits leading to functional and structural changes in an animal's economy is accounted an element of no mean weight in the *development hypothesis*, according to the testimony of able writers upon Evolution."

NOTES.

At a recent meeting of the Russian Ethnographical Society, Venioukoff read a memoir about the sect of the Skoptzi, or Castrates. It appears that these sectaries now number 5,444, less than half of them being women. St. Petersburg may be regarded as their central point, for it is from that city that the sect has spread over the rest of the country. Official notice was first taken of the Skoptzi in 1805, and then their number was only 14. Among their members are eight proprietary nobles, four of these being ladies. All classes of society are represented. The author observes that the Skoptzi are long-lived, and tall of stature. They are narrow-shouldered, have a feminine voice, and are without beard or mustache.

Patents have been issued in France for a series of machines capable of manufacturing all kinds of casks and barrels. The inventors, Messrs. Thuillier and Gerard, of Boulogne, recently gave a public exhibition of their machines, and turned out in a comparatively short space of time a large number of barrels. The machine-made ware is said to be better than that made by hand.

The census of April 3, 1871, just published, sets down the population of Great Britain and Ireland at 31,628,338, an increase of 2,557,406 in ten years, or nearly 9 per cent. Ireland decreased $6\frac{7}{10}$ per cent. in the same period. The area of England and Wales is 37,319,221 acres.

The pleasant odor of cedar, according to Mr. E. Lewis, appears to be as persistent as the wood itself. Slivers taken from white-cedar stumps found twelve feet under

water at low tide, near the Narrows entrance to New York harbor, had the odor of the newly-grown wood, and a piece not more than twice the size of one's finger perceptibly scented a drawer for more than a year. "It is certain," says Mr. Lewis, "that the coast, where the trees of which these are the stumps grew, has since undergone a depression of 18 or 20 feet, an event which may have occupied as many centuries."

THE eminent chemist, Berthelet, was lately elected a member of the French Academy of Sciences. The honor has come tardily enough, and was conferred only by the very small majority of three, sixty members voting. The *Revue Scientifique* openly charges the academicians who voted against Berthelet with bigotry, their objections being taken against the freethinker rather than against the man of science.

THE idea of making each of the several parts of many different machines interchangeable, says the *Bulletin of Wool Manufacture*, is unquestionably of American origin. Its author, a mechanic named Thomas Warner, employed in the Springfield Armory, offered the suggestion to the Ordnance Bureau, Washington, but the idea was scouted as impracticable. Mr. Warner persevered, however, and obtained a trial for his system in the Springfield establishment. It is now followed in all armories throughout this country, as well as in manufactories of sewing-machines, watches, etc. Our contemporary says: "It is this system which enables us to supply all Europe with arms, and to export sewing-machines to all the European nations, notwithstanding the vastly higher cost of our labor."

THE statistics of disease and mortality in the manufacturing establishments of the Russian Empire are absolutely startling. The number of such establishments in Russia is estimated at 90,000, and the number of work-people employed in them at 1,000,000. They are subject to numerous diseases of a serious character, among which the *factory-typhus* holds the first place. The sick-rate is from 60 to 70 per cent., and the mean duration of life is only 20 years. Rickets prevail to a deplorable extent among the youth of the working-class, and the effects of a factory-life upon children are described as disastrous. A government commission is to investigate the matter.

DE FONVIELLE calls the attention of the French Academy of Science to a remarkable passage in a work on Comets, by Hevelius, written in the year 1652; it is in harmony with the most recent observations, and is as follows: "Comets are made up of various nuclei and bodies, and hence these phenomena *do not by any means consist* of *one* solid spherical body or nucleus, as do the planets, but are made up of many different opaque nuclei and bodies, connected together, some rarer and more tenuous matter existing between, and allowing a free passage for the sun's rays."

IT is rather amusing to find Mr. Huxley mixed up with a matter of ecclesiastical concernment, but his position as rector of a university in so religious a country as Scotland makes it inevitable. A student of divinity was presented to a "bursary" in the university by the regular patron of the fund, but he was rejected by the Professorial "Senate" on the ground that he was not a member of the Established Kirk. Huxley made a speech in favor of the young man, as did also one of the professors, but the majority was opposed. The lord-rector says that he wants to know "whether the divinity classes of the Scotch universities are the exclusive property of one of the ecclesiastical bodies into which Scotland is divided, and whether the professors are to obey their church or their university?"

A NEW geological museum is to be founded in the University of Cambridge, as a memorial to the late Prof. Sedgwick. It will be known as the Sedgwick Museum, and is to be made in all respects an institution worthy of that eminent man. At the meeting held for the purpose of devising means for erecting this memorial, Prof. Humphry remarked "that for more than 54 years Sedgwick had expended £300 a year on the old museum." The committee charged with the work of obtaining subscriptions for the memorial are much encouraged by the receipt of numerous letters from admirers and old pupils of the deceased, who give every assurance of support.

THE population of the United States (excluding Indians not taxed, and the inhabitants of the Territories) was, in 1870, 38,115,641, a gain in ten years of 6,931,897, or 22.22 per cent. The highest gain of population was shown by Kansas, 239.90 per cent.; and Minnesota came next, 155.61 per cent. Louisiana shows a gain of 2.67, and South Carolina of 0.22 per cent. The greatest loss is exhibited by New Hampshire, 2.38 per cent.; and Maine comes next, with a loss of 0.22 per cent. The total increase of the white population was 24.39, and of the colored, 9.21 per cent.

SPEAKING of the Jewish element in the population of Germany, Virchow says that "it has exerted a mighty influence on our progess in civilization."

JAMES H. COFFIN.